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# PETROLEUM PRODUCT PRICE REGULATIONS:

## OUTPUT, EFFICIENCY AND COMPETITIVE EFFECTS

Scott Harvey
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STAFF REPORT OF THE BUREAU OF ECONOMICS
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by

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## PREFACE

This study of the effects of petroleum product price controls was initiated in late 1978. On January 28, 1981, the petroleum product price controls along with the crude oil price controls were removed by Executive order. Although the controls are no longer in effect, the study serves three important purposes: First, it is likely that the President's decontrol action will be debated in Congress, and it is hoped that this report will contribute to that debate. Second, the product price controls have been an important factor in the U.S. economy for nearly a decade, and it is likely that scholars will continue to study their effects and the effects of their removal. This report provides a theoretical framework which should aid in that research.

Finally, and perhaps most important, although this report focuses on the petroleum product price controls, the analytical methods and the general conclusions have broader application. Government-imposed price controls have been both debated and imposed periodically over time. It is reasonable to expect that the policy debate will continue, and many proposed controls are likely to resemble the petroleum product price controls. Those controls allowed automatic increases in a firm's ceiling price in response to increases in the firm's costs. For industries facing rapid cost inflation, that type of price control is probably the best type possible because it is relatively easy to administer and

results in fewer and less serious shortages than other types of controls. However, the analysis of this report, which could be applied to virtually any industry, shows that even this type of control can have serious adverse effects that should be carefully considered before a decision to adopt price controls is made.

This study was initiated under the direction of William S. Comanor and completed under the direction of Michael P. Lynch.

The authors are grateful for assistance from many people. Keith Anderson's efforts in reading and commenting on each of the many drafts of the study were particularly valuable. David Kaserman, of the University of Tennessee, read and commented on the entire manuscript, as did David Lean of the FTC.

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The authors are especially grateful for the work of our clerical staff. Darence Wilson typed most of the initial drafts, and the Word Processing Center staff, particularly Dianne Jones,

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Neither the individuals nor the organizations acknowledged are responsible for the views expressed in this report nor for any error that it may contain.

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## INTRODUCTION AND SUMMARY OF PRINCIPAL RESULTS

This report examines the effect of the Department of Energy
E) regulations that govern the price of refined petroleum prod-
s, primarily gasoline.[1] The price regulations under which
oline refiners and marketers operate can be summarized roughly
ollows:

> A firm may charge a price no higher than the average price it charged on May 15, 1973, plus certain increases in its average (per unit output) costs.

These regulations, which are subsequently referred to as
" regulations, are just one part of the price and allocation
lations that have governed the petroleum industry since 1973.
r components of this regulatory system include crude oil price
rols and the crude oil "entitlements" program. The regula-
s governing crude oil, which may also affect refiner behavior,
gnored in this report in order to isolate the effects of the
ct regulations.[2]

It is difficult to identify in isolation the objectives of
egulations governing the price of refined products. Certain

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thority for these regulations is contained in the Emergency
leum Allocation Act of 1973 (P.L. 94-385), extended in 1975
94-99) and amended by the Energy Policy and Conservation Act
75 (P.L. 94-163). Many of the basic provisions of the DOE
ations are mandated by these laws.

earlier FTC staff report, The Effects of Federal Price and
ation Regulations on the Petroleum Industry (December 1976),
ssed the effects of crude oil regulations.

goals of the entire regulatory program can, however, be identified.[1] First, a purpose of the program appears to be the extraction of windfall gains from crude oil producers and the transfer of these profits to petroleum consumers in the form of lower than free-market petroleum prices. Second, the protection of small and independent refiners and marketers appears to be a goal of the program. Finally, in the enabling legislation, Congress directed that DOE attempt to promote economic efficiency and to minimize interference with market mechanisms. The product price regulations appear to contribute very little to the achievement of any of these goals and may seriously undermine some of them.

Extraction of profits from crude oil producers is accomplished through the crude oil price regulations. In the early control period, the product price controls served to insure that refiners who purchased price-controlled crude oil did not merely earn higher profits as a result. However, due to the institution of the crude oil "entitlements" program, market forces now tend to extract the crude oil profits from refiners and marketers with relatively little additional contribution from the product price controls.[2] In addition, with the entitlements program, market forces cause the extracted crude oil profits to be passed on by refiners and marketers in the form of lower product prices. The

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1 Additional discussion of these goals, ibid.

2 For an explanation of the entitlements program's effects, ibid., pp. 52-56.

product price regulations may eliminate some profits (from various sources) that the entitlements program alone would allow refiners and marketers to capture, and the product regulations have some tendency to cause these profits to be passed through as reduced product prices.[1] However, the product price regulations also cause constrained firms to adopt costly production methods. As a consequence, the profits extracted by the product regulations can be used up in higher production costs; and prices paid by consumers may actually be higher than they would be in the absence of product price ceilings.

While various parts of the product regulations appear to be aimed at helping independent marketers, the analysis in this report suggests that the net effect of the regulations is likely to be harmful to these firms. The product price regulations have a strong tendency to increase the market shares of vertically integrated firms at the expense of their nonintegrated competitors.

Finally, although price regulation is inherently contradictory to a goal of minimizing interference with market mechanisms, the DOE regulations have managed to preserve, to a greater extent

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[1] One type of profits that the price controls could possibly reduce is that stemming from market power on the part of refiners and marketers. However, insofar as monopoly pricing predated the regulations, the regulations would probably not be effective in eliminating monopoly profits. The product price regulations were neither instituted nor designed to address competitive problems in the domestic industry.

than many price regulation schemes, an important market mechanism. The DOE price controls, even when binding, generally promote prices that balance supply and demand (particularly at retail). Thus, the market mechanism is allowed to allocate available supplies among final consumers efficiently and without the need for administrative rationing. Even in this regard, however, the regulations reduce market flexibility to the extent that the long gasoline lines and other disruptions that occur when demand exceeds supply will result more frequently than they would in the absence of price controls.

PRINCIPAL ANALYTICAL RESULTS

The analysis of this report identifies a number of problems with the regulations. The most important of these are listed below with brief explanatory comments.

1. The regulations induce refiners to use refining methods that are unnecessarily costly.

The regulations generally allow refiners to recoup increased costs by increasing their ceiling prices. However, certain types of cost increases cannot be recouped fully. Refiners operating under the regulations have an incentive to favor production methods that allow the greatest cost recoupment even if those methods are not most efficient.

Throughout the history of the regulations there has been a concern that the regulations do not allow refiners adequately to

ecoup capital costs and that investment in refining capacity is hereby discouraged. The fear seems to have been that inadequate nvestment in refining capacity would lead to shortages. A more ikely effect is that refiners will meet increased demand at an nnecessarily high cost. Increased gasoline output can generally e achieved by using higher quality crude oil, using more hemicals, burning more fuel to generate higher process tempera- ures, adding simple refining equipment, or in a number of other ays. The most economical method of increasing output, however, ay require heavy investment in sophisticated refining equipment. f the regulations allow a smaller proportion of capital costs han of other costs to be recouped, refiners may obtain the ighest profits by using the more costly methods of increasing tput that require relatively little or no capital investment.

The use of inputs other than capital can also be distorted ecause the regulations also allow different proportions of their sts to be recouped.

2. The regulations can cause refiners to make inefficient purchases of gasoline from other refiners.

As indicated above, the regulations give refiners a profit tive to favor production methods whose cost can be most easily couped through ceiling price increases. The cost of purchasing soline that is subsequently resold can be fully passed through the ceiling price. Gasoline purchases are therefore a very

attractive means of expanding output. This can lead refiners to meet gasoline demand by purchasing gasoline when they could obtain it at a lower cost by refining it themselves.

3. The regulations can cause prices to be higher than they would be in the absence of regulation.

The inefficient selection of inputs and the inefficient purchases of gasoline serve to increase the cost to refiners of satisfying the demand for gasoline. As a result, the cost of producing additional gasoline is likely to be higher under the regulations than it would be in a free market. While the regulations tend to force refiners to price lower than they would in a free market relative to their cost of producing additional gasoline, the adverse effects of the regulations on production costs create a definite possibility that prices under the controls may be above the free market level.[1]

This fact has not been widely recognized. Even when advocating gasoline price decontrol, DOE has invariably predicted that decontrol would cause higher prices. These projections have led

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[1] This does not mean that prices would be likely to fall if gasoline price controls were removed. The costs of refining and marketing are rising over time, as are most costs in the economy. As a result, gasoline prices have been rising under the controls and this trend is apt to continue following decontrol. Price increases may, however, be smaller if the gasoline price regulations are removed than they would be under continued regulation. It should also be noted that crude oil price regulations work differently than the gasoline price regulations. Deregulation of crude oil prices, while having desirable efficiency effects, will inevitably cause price increases.

to the concern that decontrol might cause inequities and that it would increase inflation indexes. However, DOE price predictions have apparently failed to consider the effect of production inefficiencies that can push up costs in the regulated environment. While it is very difficult to measure the impact of these inefficiencies, ignoring them biases upward the projected price changes due to decontrol.

Some of the inefficiencies induced by the regulations may involve capital investments and therefore may be reversible only in the long run. Others, however, such as the decision to purchase product at high cost rather than refining it at a lower cost internally, can be reversed in the very short run. This opens the possibility that there could conceivably be favorable effects on price trends soon after gasoline decontrol.

It might seem that refiners would generally oppose gasoline decontrol if it would lead to lower gasoline prices. This conclusion would be incorrect. Because refiners are required to incur unnecessarily high costs to secure the high prices, the net effect of the regulations on their profits will generally be negative.

4. The regulations cause resources to be expended producing additional gasoline when those resources could be better used to supply consumers with more valuable commodities. This happens because the regulations cause the cost of producing additional gasoline to exceed the price of gasoline.

If the price of gasoline equals the full cost of producing an additional gallon, consumers will make the proper decisions about

when to conserve and when to use gasoline. They will consume only if the use to which the gasoline will be put has a value at least as great as the cost of the resources used to produce an additional gallon. If the cost of making an additional gallon of gasoline is greater than its value to the consumer (its price), the consumer could be better served if the additional gasoline was not produced. The resources saved by not producing the gasoline could produce something else of greater value to the consumer.

In an unregulated market, firms would never find it profitable to persistently produce additional gasoline at a cost greater than the price at which it could be sold. In a competitive market, market forces tend to cause unregulated firms to equate the cost of supplying an additional gallon with the market price. Under the regulations, there is no such tendency. Firms affected by (constrained by) the regulations will expand gasoline output to the point that their cost of supplying the additional gallons exceeds the price at which they sell it. The regulated refiners find such sales profitable because they are then allowed by the regulations to increase the price they charge for other units of output that were less costly to produce. The ceiling price formula is constructed so that the added revenue from selling other units at a higher ceiling price more than makes up for selling the added gasoline output at a loss.

5. The regulations may induce refiners to import excessive amounts of crude oil and petroleum products.

The regulations' tendency to hold the price of gasoline below the cost of producing additional gallons artifically stimulates the demand for gasoline. Since imported crude oil is a key input to producing additional gasoline, it is likely that crude oil imports will be used to meet that demand. Even if the regulations result in a lower total output of gasoline than would result in a free market, crude oil imports may be higher than they would be in a free market. The regulations can discourage investment in sophisticated capital equipment that could allow refiners to substitute low quality crude oil that is relatively abundant in the United States for high quality crude oil obtained from abroad.

Gasoline imports may be encouraged by the regulations even when foreign gasoline prices are at very high levels because, as noted above, the price regulations make purchasing gasoline a relatively attractive means for refiners to increase their supplies. Under certain circumstances, domestic refiners may be able to buy only from foreign refiners who are not subject to the regulations.

6. The regulations can cause the market shares of firms with relatively high costs to expand while the shares of firms with relatively low costs contract. Consequently, industry output may be produced at an unnecessarily high cost.

In the absence of price regulations, competitive market forces tend to cause additional output to be supplied by the firm that can produce it at the lowest cost. When this happens, sales are distributed among firms in such a way that industry costs are minimized. The regulations cause a firm's market share to be heavily influenced by arbitrary factors such as its prices and costs at the outset of the regulations and its ability to exploit the market distortions caused by the regulations. Under the regulations, therefore, regardless of the degree of competition, there is no tendency for the distribution of market shares to result in cost minimization.

7. The regulations can cause independent service stations to be squeezed out of business and may promote excessive vertical integration of petroleum companies.

Integrated firms (those that both refine and retail gasoline) can be induced by the regulations to retail additional gasoline at a price that is lower than the cost to them of making the sales. This may "squeeze" the profit margins of the integrated firms' competitors, the independent retailers who do not have their own refineries, and may cause the independents to go bankrupt. One cause of this result is the pricing effect of the regulations described under point 4. The ceiling price formula is constructed so that sellers whose operations are affected by (constrained by) the regulations find that the added revenue from selling all their output at a higher ceiling price more than makes up for selling

the added output at a loss. Integrated retailers are more likely than independent marketers to be constrained by the ceiling price provisions, because all of a firm's petroleum operations are combined for the purpose of computing ceiling prices, and the price rules have tended to be much more restrictive of refining operations than of marketing operations.

In addition, the regulations give integrated refiners an incentive to retail for themselves some of the gasoline that in a free market they would channel through independents. This incentive arises because the price ceiling formulas generally allow a firm a somewhat higher average profit margin when it sells a greater proportion of its output to retail customers. The ceiling price formula causes the higher cost of marketing at retail rather than at wholesale to be treated erroneously as a general inflation in marketing costs. As a result, the regulations give a refiner an incentive to reduce his sales of gasoline to independent marketers and to sell the gasoline through his own retail outlets instead.

It might be thought that the gasoline allocation regulations would prevent refiners from bypassing their historic wholesale customers. However, refiners can manipulate their ceiling price structure to make the purchase of their gasoline at the wholesale level unattractive.

8. The regulations' effects may be much more persistent and widespread than has generally been recognized. The absence of gasoline lines and other signs of shortages does not mean that the regulations are having no effect on the production or price of gasoline.

Standard textbook descriptions of price controls conclude that there will be shortages whenever price controls are actually having an effect on sellers. Those textbook conclusions have apparently led many to believe that there has been no reason for concern about the effects of gasoline price regulations except during the infrequent periods of shortage. This study shows that the standard textbook exposition of price controls does not properly capture the effects of the gasoline price regulations. The gasoline price regulations allow sellers to increase their prices when they incur additional costs, and the regulations generally give sellers an incentive to push their prices and output up to the point at which any consumers willing to pay the prevailing price will be able to buy as much gasoline as they want. Therefore, the many adverse effects of the regulations that are indicated by this study may be occurring even when gasoline is readily available at any service station.

9. So long as the regulations are in effect, long gasoline lines and other indications of shortages can be expected to occur sporadically.

The gasoline price regulations allow much more pricing flexibility than traditional price ceiling regulations, but there are a number of circumstances in which the regulations are likely

to cause shortages. Widespread shortages are most likely to accompany unusually rapid increases in refinery costs or demand. Shortages have occurred, for example, during periods when world crude oil prices have shot up due to wars or embargos disrupting supplies. The regulations are likely to cause shortages in these circumstances because ceiling price changes follow cost changes by a month. This regulatory lag can make it very unprofitable for sellers to supply enough gasoline to meet demand during periods of rapid cost increases.

Shortages are also likely to result when the relative cost of supplying buyers in different economic markets changes significantly. If a supplier sells to various categories of buyers, such as wholesale and retail buyers or buyers in various geographic areas, the regulations allow a different ceiling price for each category to reflect the differing costs of supplying them. However, the allowed differences in ceiling prices cannot be altered to reflect changes over time in cost and demand conditions. As a result, sellers may find it unprofitable to meet demand in certain markets.[1]

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[1] This second type of shortages was caused by the "equal application rule." That rule was suspended in November 1980, after the analysis of this report was completed.

10. The adverse effects of the regulations identified in this report are mostly of a fundamental nature. It cannot be expected that modification of the regulations will significantly reduce the problems identified without causing other, equally severe problems.

While it might be tempting to blame the problems identified above on poor regulatory design and implementation by DOE, similar problems can be expected whenever a complex industry is subjected to prolonged price regulation.

On the surface, it appears that many of the problems could be easily remedied by changes in the regulations. This appearance is deceptive. Certainly some of the adverse effects could be eliminated; but in each case, for theoretical, practical or administrative reasons, possible remedial actions encounter problems. For example, the incentive to use costly refining methods could be eliminated by allowing the same proportion of all types of costs to be passed through. While that is true in theory, the practical difficulty of measuring the cost of equity capital or the cost of producing a particular product, such as gasoline, that is produced jointly with other products has not been surmounted in simpler regulated industries. As another example, inefficient purchases of refined product for subsequent resale could be eliminated by not allowing refiners to purchase for resale. That action, however, would greatly increase the probability of long gasoline lines and would motivate refiners to augment their output using even less efficient means. Remedies to other problems would

greatly increase the administrative costs of the regulations and could also increase the probability of shortages.

THE ORGANIZATION OF THE ANALYSIS

Three basic models are employed to develop the results of the report. Each model is a somewhat more detailed version of the one that precedes it. Complexity is added only as necessary to examine relevant policy questions and to test the sensitivity of the results to simplifying assumptions.

Chapter I is less technical than the other chapters and is intended to give intuitive insight into the formal models. It provides a systematic overview of the report's analysis, but it is intentionally oversimplified and not intended to "prove" any results.

The first formal model is introduced in chapter II. It assumes a single petroleum product and no marketing activities. This single-product model serves to introduce, in a simplified context, the basic nature of the controls. In addition, it provides a reasonably good representation of the effects of the regulations during the period immediately prior to 1976, when all product prices were regulated.

The second basic model, introduced in chapter III, assumes two products in order to examine the implications of deregulation of some products. This model also introduces marketing as an activity distinct from refining and recognizes the ability of refiners to purchase product from other refiners to resell. In

addition, the second model allows inferences about the indirect impact of the regulations on nonintegrated gasoline marketers.

Chapter IV explores the consequences of modifying the first two basic models. First, the impact of the "tilt" modifications on the price regulations is explored. Second, the assumption that the regulated firms are price takers is relaxed in order to examine the predictions under the assumption that the firms have market power.

The third model is introduced in chapter V. This model allows for the possibility that a refiner may be only partially integrated, selling some product to independent marketers as well as performing marketing functions himself. This allows additional inference about the tendency of the regulations to encourage vertical integration.

In chapter VI, the effect of the allocation regulations on the partially integrated refiner of chapter V is discussed, as is the effect of the limitation on the pass-through of nonproduct marketing costs.

Chapter VII discusses the possible causes of observed shortages, and the final chapter discusses the implications of the report for empirical analysis. The discussion uses as an example the question of whether the price controls have generally been binding or nonbinding.

# CHAPTER I

## EXPLANATION OF THE ANALYTICAL RESULTS

The DOE price regulations under which refiners and marketers operate can be summarized roughly as follows:

> A firm may charge a price no higher than the average price it charged on May 15, 1973, plus certain increases in its average (per unit output) costs.[1]

This summary description ignores a myriad of complexities embodied in the actual regulations,[2] but it conveys the essential differences between traditional price controls and the petroleum product price controls. The most important difference is that, under the petroleum price regulations, the individual firm has some control over its ceiling price, whereas traditional government-imposed price ceilings have been exogenous to the firm. The petroleum price ceiling is not invariant over time or across firms but depends upon the costs that the individual firm incurs. The firm does not have "a" ceiling price; it has a schedule of ceiling prices related to its average cost. As a result, the firm has a good deal of room within which to alter its behavior in order to increase its profits. A number of the primary analytical results in this report stem from the flexibility in the price ceiling and the relationship between the price ceiling and average cost.

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[1] In the event that the specified average costs went down, the ceiling price would be reduced correspondingly.

[2] A number of the complexities are incorporated in the rigorous analysis in the body of the report.

Another interesting characteristic of the product price controls is that because they are based on firm-specific factors, they may be binding on some firms while other firms in the same market remain unconstrained.

There are three fundamental supply effects of the DOE price controls that interact to generate most of the analytical results; these are labeled the "market clearance effect," the "average-cost-supply effect," and the "costly-supply effect."[1] First, even when the DOE price controls are binding, constrained firms will frequently price at a level that balances supply and demand. This is the "market clearance effect." With traditional price controls, the ceiling price is exogenously determined.[2] The traditional controls are binding if the supply and demand curves intersect above the exogenous ceiling price; and binding controls are, therefore, signaled by a shortage. The reason that the DOE controls have a different effect than traditional price controls is that under the DOE controls, the firm's ceiling price rises with increases in its output. If the ceiling price is below the

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1 The discussion in this chapter is intended to give some intuitive insight into the economic forces that underlie the results of the analysis. The exposition is intentionally oversimplified and is not intended to "prove" the results. More rigorous proofs are incorporated in the body of the report.

In this overview, it is assumed that the regulated firms are price-takers. Some of the explanation would be altered if the firms were assumed to perceive downward sloping demand curves. For a discussion of the differences, see chapter IV.

2 The traditional analysis is summarized in the appendix to this chapter.

market clearing price, the regulations generally allow a refiner or marketer to produce (or purchase for resale) more product and to raise his ceiling price sufficiently to recover the cost of the additional product and make a profit margin on each unit. As a result, firms will generally find it profitable to increase their output until their ceiling price rises to the market clearing price level. The ceiling price therefore tends to balance supply and demand.

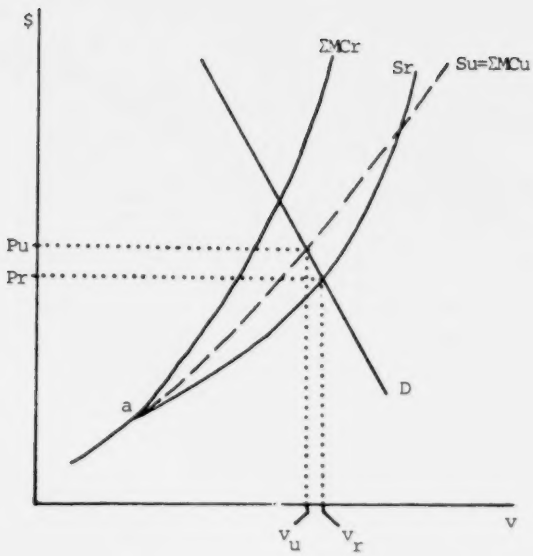
The "average-cost-supply effect" and the "costly-supply effect" tend to oppose each other. On the one hand, the regulations when binding induce each firm to supply product along a curve that lies below and to the right of its marginal cost curve. This is the "average-cost-supply effect." It results because the ceiling price is based on the firm's average cost (which is below marginal cost for constrained firms) with only a limited profit margin allowed on each additional unit of output. Firms can find it profitable to supply at a price below marginal cost because of the way the ceiling price tends to increase with increased output. Even though the increased ceiling price is lower than marginal cost, the fact that the raised ceiling also applies to infra-marginal units of production can make the output expansion profitable. In other words, the firm's ceiling price generally rises with output at a rate that causes marginal revenue to exceed marginal cost as long as buyers are willing to pay the ceiling price. Since unregulated firms supply along their marginal cost

curves, the average-cost-supply effect, all other things being equal, would imply that the regulations increase industry supply.

On the other hand, the regulations when binding also give profit incentives to firms to deviate from cost minimization. This causes their marginal cost to be higher than it would be in the absence of regulation. This is the "costly-supply effect." The incentives to deviate from cost minimization arise because different types of costs are treated differently by the regulations, and the profit margin earned on incremental output may be lower if the firm supplies the incremental output at minimum cost. All other things being equal, the costly-supply effect would imply that the regulations decrease industry supply.

Figure 1-1 can be used to depict these three effects of the DOE controls. The dashed curve labeled Su is the industry supply curve in the absence of regulation. It includes the solid section below point "a" over which the regulations are assumed to be non-binding for all firms. In an unregulated market, firms maximize profits by minimizing cost. Therefore, curve Su is the horizontal sum of the individual firms' marginal cost curves when they minimize costs. Due to the costly-supply effect discussed above, the sum of the firms' marginal cost curves under regulation would lie above Su and might be shown by curve ΣMCr. Since the average-cost-supply effect causes the regulated supply curve to lie below the regulated industry's marginal cost curve, the regulated supply curve might be shown by a curve such as that labeled Sr.

Figure 1-1



Note for future reference that curve Sr lies to the right of the actual marginal cost curve but not necessarily to the right of the cost-minimizing marginal cost curve shown by Su. Therefore, as compared to the unregulated supply, the regulated supply may be greater or less, depending on the price level.

MARKETING CLEARING PRICES

In figure 1-1 the regulated supply curve is shown to intersect the demand curve at Vr, Pr. Because of the market clearance effect, it is likely that in the regulated equilibrium, constrained firms will have a ceiling price equal to Pr and that supply and demand will be balanced. Recall that when the firm's ceiling price is below the market clearing price, the regulations frequently allow the firm to increase its output and raise its ceiling price sufficiently to recover the cost of the additional output and make a profit margin on each unit. For this reason refiners will frequently find it profitable to select an output at which the ceiling price equates supply and demand.

The market clearing result is interesting for two reasons. First, the ability of the regulations to mimic the free market in this respect is one of their cardinal virtues. Market clearing prices insure that available supplies are distributed to the highest valued uses. In addition, there is no need for the difficult and politically sensitive process of administrative rationing.

The market clearance question is also important for the following reason. This report shows that the regulations have a number of adverse effects on economic efficiency. These effects will occur, however, only when the regulations are binding. If the absence of a shortage necessarily implied that the regulations are not binding, it could be concluded that the efficiency effects of the regulations have rarely been a real problem. This conclusion would follow from the observation that shortages have rarely occurred during the period of regulation. On the other hand, if the regulations can be binding without creating shortages, the possibility must be recognized that the inefficiencies have been and are persistent and serious.

While market clearance is likely when the regulations are binding, there are two features of the regulations which can cause localized or transient shortages to develop. First, while the regulations allow a great deal of flexibility in a seller's overall price level for each product, most firms sell each of their products in a number of distinct markets; and the regulations provide very limited flexibility for changes in ceiling price differentials among markets.[1,2] As a result, some firms may find it

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1 This includes geographical markets and functional (e.g., wholesale, retail) markets.

2 This limit on flexibility arose because of the equal application rule. The equal application rule was suspended on November 1, 1980, after the completion of this analysis.

profitable to operate with a ceiling price below the market clearing price in some markets while their ceiling price clears other markets.

The second possible cause of excess demand is a form of regulatory lag. A firm's ceiling price in the current month is based on its costs in the preceding month. Consequently, during months in which there are significant cost increases (especially if those increases are unanticipated), many firms may be unable to profitably achieve a market clearing ceiling price in any market.

AVERAGE-COST SUPPLY: THE IMPACT OF PRICES BELOW MARGINAL COST

As discussed above, the regulations, when binding, induce firms to price below their marginal cost--at a level closer to their average cost than they would freely choose. Recall that firms can find it profitable to supply product at a price below marginal cost because of the way the ceiling price tends to increase with increased output. Even though the increased ceiling price is lower than the marginal cost of additional product, the fact that the new ceiling price also applies to inframarginal units of production can make the output expansion profitable.

This average-cost-supply effect has four major effects. First, economic rents are extracted from the firms. Second, prices to consumers may be lower. Third, there is a misallocation of resources toward supplying petroleum products at the expense of other commodities. Fourth, there is an inefficient distribution of productive activity (i.e., market shares) among firms in the

industry. The first two effects--extraction of rents and possibly lower prices--are presumably effects sought by the regulations. These desirable effects are accompanied, however, by undesirable inefficiencies--the allocation of excessive resources toward supplying petroleum products and distorted market shares. These four effects are discussed individually below.

Misallocation of Resources--Excess Crude Oil Imports

The market clearing price of a commodity indicates the value that consumers place on incremental quantities of the commodity. When the market clearing price is below marginal cost, it means that the value to consumers of the resources used to produce incremental units of the commodity is higher than the value to consumers of those incremental units. Therefore, since the regulated price of petroleum products is below their marginal cost, the resources used to supply incremental amounts of petroleum products could be transferred to the production of other commodities that consumers would value more highly.

One of the major inputs to supplying incremental petroleum product is imported crude oil. The implicit subsidy the price regulations give to petroleum products is doubly unfortunate if it results in the use of excessive amounts of imported crude. First, extra imports of crude oil put resources (labor, materials, etc.) under the control of the oil-exporting countries (through their acquisition of dollars paid for that crude oil). Second, the higher level of imports may make the United States more susceptible to economic blackmail by foreign oil-producing countries.

The misallocation of resources is a fundamental problem of the product price regulations. The simultaneous combination of a price lower than marginal cost, market clearance, and an efficient level of output is simply not possible. If rents are to be extracted from firms by inducing them to price below their marginal cost, an efficient level of output can result only if output is restricted below the market clearing level.[1] That would, however, eliminate the most significant virtue of the present regulations--their ability to allocate available supplies with market clearing prices.

Market Shares Do Not Reflect Efficiency

A second inefficiency caused by the average-cost-supply effect is the distortion of firms' market shares. In equilibrium, firms bound by the controls are equating their ceiling price to the market price. Since each firm's ceiling price is only roughly related to its average cost and is completely unrelated to its marginal costs, the regulated firms will have varying marginal costs in equilibrium. This is in contrast to an unregulated equilibrium in which price-taking firms equate their marginal costs to the common market clearing price. The regulated equilibrium is inefficient because if one firm has a higher marginal cost than

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[1] This ignores the question of how the appropriate level of output--that output at which the marginal value of petroleum products equals their marginal cost--could be determined in the absence of market transactions and the question of how the production of that output would be distributed among refiners.

another, resource savings could be achieved (without reducing output) by shifting production from the firms with high marginal cost to those whose marginal costs are lower.

It appears likely that along with other market share distortions, product price controls systematically work to reduce the market shares of independent gasoline marketers who face competition from integrated refiner-marketers. This effect is discussed in more detail below, along with other regulatory inducements to increased vertical integration.

Extraction of Rents

A result of the average-cost-supply effect that is in correspondence with the apparent goals of petroleum regulations is the extraction of economic rents from refiners and marketers. Economic rents in general accrue to a firm when it is able to sell at a price that exceeds its average cost. In the short run, this frequently occurs due to capital limitations, and it may persist over a considerable period of time for a firm that has access to inframarginal factors of production at a low cost.[1] By forcing

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1 As mentioned above, the crude oil entitlements program eliminated the preexisting potential for unregulated refiners to earn huge rents based on their access to inframarginal price-controlled crude oil. However, there are flaws in the entitlements program that still allow refiners access to some potential rents from their crude oil allocations. These arise primarily from the fact that crude oil entitlements payments are based on average crude oil values for broad categories of nonhomogeneous crude oils. As a result, the post-entitlements cost of some price-controlled oil continues to understate its true marginal value. This was discussed in detail in comments of the Bureau of

(footnote continues on next page)

prices toward average cost, the product price controls limit refiners' and marketers' ability to capture these potential rents.

Lower Product Prices?

The average-cost-supply effect can result in prices being lower than they would be in the absence of regulation. For example, the regulated equilibrium illustrated in figure 1-1 is characterized by a lower than free-market price. The regulated equilibrium price would be Pr while the price in the absence of regulation would be Pu. In essence, the regulations extract rents from a constrained refiner and allow him to earn some of them back by increasing his output. The result may be a higher output and, consequently, lower prices than would occur in a free market.

Reduced prices are certainly a goal of the regulations and the presumption that they are obtained is probably the primary reason that product controls have been maintained.[1] Many proponents of the regulations appear to recognize the adverse efficiency effects of the regulations but are willing to accept those

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(footnote 1 continued from previous page.)

Competition of the Federal Trade Commission to the Economic Regulatory Administration of the Department of Energy Concerning the Competitive Impact of Wellhead Price Ceilings, Entitlements, The Reseller Rule, The Supplier/Purchase Rule (May 23, 1978).

1 If lower prices do not result, both consumers and producers are worse off, and the extraction of rents from controlled firms is merely punitive.

problems in return for the lower prices that they believe the regulations inevitably produce.

HIGHER PRODUCT PRICES DUE TO COSTLY SUPPLY?

The product price regulations do not, however, necessarily result in lower product prices. In contrast to traditional price controls, the petroleum product price controls may result in higher than free-market prices when they are binding.

Regulated prices that are higher than free-market prices can result if the costly-supply effect overrides the average-cost-supply effect. In figure 1-2, for example, a higher price (Pr) results under regulation than in the absence of regulation (Pu). Determining whether the supply-increasing or supply-reducing effects of the regulations dominate and thus, whether the regulations result in higher or lower prices, would be a very difficult (perhaps impossible) empirical task.[1]

It appears that the costly-supply effect and its potential to cause higher than free-market prices have generally been overlooked. It has certainly not been apparent in the debate over petroleum product deregulation. DOE has on occasion estimated that price increases of various sizes might accompany gasoline decontrol.[2] The theory underlying those estimates has never been

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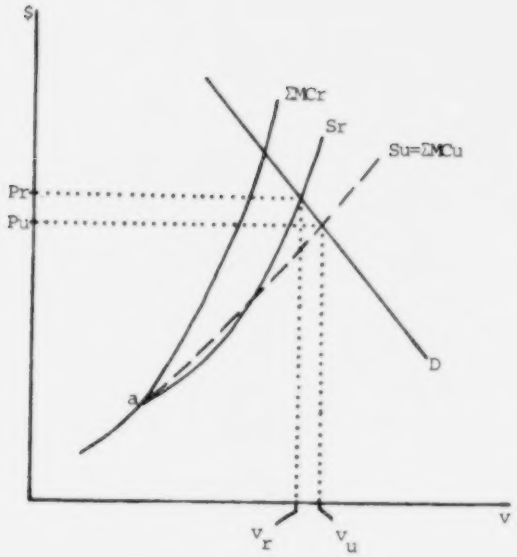
1 Recall that the regulations affect each firm differently.

2 For example, see U.S. Department of Energy, Final Environmental Impact Statement: Motor Gasoline Deregulation and the Gasoline Tilt, January 1, 1979.

Figure 1-2



clearly spelled out, but it appears from the published calculations that the estimates have reflected the average-cost-supply effect of the regulations and have not taken into account the costly-supply effect. In terms of figure 1-2, it seems that the estimates have essentially assumed that the curve $MC_r$ would be the supply curve in the absence of controls. Making this implicit assumption biases upward the estimated price change due to decontrol and may cause a positive estimate when the correct prediction would be a price decrease.

The strongest price-oriented argument that proponents of decontrol have marshalled is that product controls are generally nonbinding and thus do not lower prices. Opponents of decontrol have responded, however, that the nonbindingness argument is unconvincing; and that even if the controls are nonbinding now, they may become binding and result in lower prices in the future.

The recognition that the product price controls may cause higher than free-market prices adds another dimension to the decontrol debate. It must be recognized that continuation of the controls, rather than exchanging efficiency for equity (in the form of lower prices to consumers), may sacrifice both efficiency and lower prices.

It might be thought that refiners and marketers would not oppose the regulations if the regulations resulted in a higher than free-market price. This conclusion would be incorrect. Although when the costly-supply effect dominates, refiners and marketers get a higher price than they would in the absence of

regulation, on average they get a lower profit.[1] Constrained firms are required to incur costs to secure the increased price. Regulated firms increase their profits by using inefficient production methods, but this is an increase only relative to the regulated profit if cost-minimizing methods were used. Profits are still lower than if there were no controls.

It might be thought that if the regulations result in high prices there would at least be the favorable side effect of lower crude oil imports. This conclusion might be drawn from the observation that regulated output must be lower than the unregulated output whenever the regulated price is higher than the unregulated price. However, when some of the particular inefficiencies that cause the costly-supply effect are discussed below, it will be shown that this side effect is not certain. Because of the regulations, refiners could use more imported crude oil than they would in the absence of regulations even though they produce less product.

The analysis of this report suggests that constrained regulated firms are likely to engage in at least three types of production inefficiency that contribute to the costly-supply effect. These are: the failure to select a cost-minimizing input mix,

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[1] This should be true in general, although due to the uneven effects of the regulations on individual firms it may not be true for every firm. Some firms may even earn a higher profit than they would in the absence of regulation even if the regulated price is lower than the free-market price.

the purchase of gasoline from other refiners when it could be acquired at a lower marginal cost by refining it internally, and the use of inefficient channels of marketing. Each of these inefficiencies and its importance is discussed in turn below.

Costly Input Mix

The regulations can cause refiners and marketers to deviate from cost minimization in their choice of inputs (e.g., capital, crude oil, fuel, etc.). The regulations tend to allow different fractions of the cost of different categories of inputs to be passed through in the ceiling price. In attempting to maximize their profits, firms bound by the regulations have an incentive to favor those types of inputs for which a greater fraction of the costs can be passed through.[1]

A firm is generally able to produce a particular amount of output with any of a large number of input combinations. An unregulated firm (because the price it receives is independent of the costs it incurs), will maximize profits by selecting the mix of inputs that minimizes its cost.[2] Since the price received by a firm bound by the petroleum price regulations is not independent of the type of costs it incurs, the regulated firm can usually

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1 This incentive is countered by a regulatory profit incentive to maximize sales that tempers the deviation of the firm from cost minimization. Thus, firms will not completely avoid the inputs whose costs are most difficult to pass through.

2 This is also true for firms bound by the traditional type of price control analyzed in the appendix.

increase its revenue more than it increases its costs by deviating from the cost-minimizing input mix.

Prior to a modification in the regulations in March 1979, constrained refiners and marketers were given a clear incentive by the regulations to use an inefficiently low ratio of capital to other inputs. This incentive arose because the regulations did not allow any increases in one component of capital cost--the equity cost--to be passed through. Consequently, a firm could pass through a greater fraction of the cost of noncapital inputs such as labor, fuel, and crude oil than of capital inputs. In such a situation, the firm will prefer to use noncapital items as substitutes for capital inputs, even though this increases the total cost of production.[1]

In March 1979, the situation was complicated considerably by a change in regulations (called "tilt"), which specified that refiners could pass through different fractions of crude oil costs and non-crude oil costs. The difference in the fractions was made a function of the proportion of gasoline in the refiner's total output. This change in regulations made it impossible to determine, without extensive (firm-specific) empirical information, which inputs were likely to be employed in greater and which in less than efficient proportions.

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1 For example, a refiner might burn more fuel to achieve a higher processing temperature and thus produce more gasoline with existing equipment rather than installing additional equipment to achieve the same output with lower fuel use and a lower total cost.

The conclusion that constrained refiners are unlikely to use a cost-minimizing input mix continues to hold, however; and the possibility that the regulations give incentives to refiners to use a low capital input ratio still exists.

The possibility that the regulations give refiners disincentives to capital investment is one of the reasons for the warning in the preceding section that a below-free-market output (and above-free-market price) might not imply less than free-market crude oil imports. A possible manifestation of a reluctance to invest in capital equipment could be a reduced ability of domestic refiners to process low-quality (heavy and high-sulfur) crude. Low-quality crude oil requires additional processing with sophisticated equipment to yield the product mix suited to U.S. demands. Low-quality crude oils are now (relatively) abundant from domestic sources (especially Alaska and California), while high-quality crude oils are available at the margin only from abroad. Even though the additional crude oil cost from using high-quality foreign crude oil might be higher than the capital cost necessary to achieve the same output with cheaper, low-quality domestic oil, the increased crude oil costs may be easier to recover under the price regulations and therefore be the more profitable choice. This means that the regulations may indirectly result in refiners substituting foreign for domestic crude oil. Since this phenomenon can accompany a lower than free-market

output induced by the costly-supply effect, higher prices together with higher imports is a possible regulatory effect.[1]

The Purchase of Refined Product for Resale

A second cause of the costly-supply effect is that the price regulations may make it profitable for refiners to meet some market demand by purchasing product from other refiners even though the purchasing refiner could refine the product himself at a lower marginal cost. This occurs primarily because the simple formulas incorporated in the price regulations to apportion refinery costs between regulated petroleum products (now primarily gasoline) and unregulated products are likely to understate the true cost of expanding gasoline output when refinery throughput exceeds some level. On the other hand, when the refiner purchases gasoline for subsequent resale, the regulations allow the full cost of the purchased product to be recovered through ceiling price increases.

The product-purchase inefficiency can be seen as a special case of inefficient input choice by viewing purchased product simply as another input that contributes to the refiner's total output of refined product. However, product purchases are noteworthy for a number of reasons. First, purchased product is treated differently from other inputs in the price ceiling formula

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[1] Regulatory investment disincentives might also inhibit other behavior, such as inventory buildup, that could lessen the severity of foreign supply disruptions.

and thus must be modeled separately. Second, the tendency of constrained refiners to purchase gasoline to reach equilibrium can intensify the regulatory pressures on independent marketers who must compete for those same gasoline supplies. These pressures are described in the next section. Finally, now that many refined products have been deregulated, it is the ability of refiners to purchase gasoline that underlies the conclusion that market clearing prices are likely to prevail when the regulations are binding.

The last point above is one reason why the purchased-product inefficiency cannot be painlessly eliminated simply by prohibiting product purchases by refiners. Such a prohibition would greatly increase the likelihood of shortages. In addition, some product purchases are likely to contribute to efficiency. Even in unregulated markets, refiners buy product from one another, and under the right conditions, the practice can be an efficient way to rectify regional supply and demand imbalances. Administratively distinguishing between efficient and inefficient transactions would probably be impossible, and the net effect of a blanket ban could be to increase costs. Finally, even if inefficient purchases alone could be banned, it is quite possible that regulatory incentives might lead refiners to choose an even less efficient means of expanding their sales. Due to the complexity of overlapping inefficiencies inspired by the regulations, it is often difficult to be sure that stopping one inefficient practice will not lead to behavior that is even more inefficient.

Both the refinery input mix and product purchase inefficiency stem from a failure of the price ceiling formula to reflect properly certain elements of costs to firms. It is tempting, therefore, to conclude that these adverse efficiency effects could be easily eliminated by revising the price ceiling formulas to reflect actual costs. However, an accurate method of determining the relevant costs would first have to be devised.

The two types of cost that are misspecified by the DOE regulations are the equity cost of capital and the cost of producing a particular product in a multiproduct production process. Determining these costs is a traditional problem of regulation and one for which a good solution has not been found.[1] While it is likely that the DOE regulations could be improved somewhat in this respect, it is very unlikely that they could be perfected. Also, any improvement would probably entail correspondingly increased administrative expenses.

The Promotion of Vertical Integration

Elements of both the average-cost-supply effect and the costly-supply effect tend to promote inefficient vertical integration and can lead to the displacement of independent firms. The displacement of independent marketers, especially retailers, appears to be a very likely result of the regulations. This is in

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[1] See, for example, Alfred E. Kahn, The Economics of Regulation: Principles and Institutions, New York: John Wiley & Sons, Inc., 1970, especially Volume I, pp. 45-54 and pp. 77-83.

contradiction to one of the expressed goals of the regulations--the protection of small and independent marketers.

As noted above, the average-cost-supply effect results in an inefficient distribution of output among firms. It is probable that this effect has systematically worked to the disadvantage of independent marketers. Because of the relationship between base period and current period prices and costs, the price ceiling formulas applied to marketing operations alone have generally been nonbinding. Thus, independent marketers have generally been unconstrained. However, in computing ceiling prices for integrated firms, the regulations lump the marketing operations with the refining operations. The integrated refiner-marketers can thus be constrained because of their refinery operations.

In such a case, the integrated firms maximize their profits by accepting a lower marketing margin than would be optimal absent regulations and by expanding their marketing volume. It may be profitable for a constrained integrated refiner to accept a margin between the wholesale and the retail price of gasoline that is so low that independents who compete with him will be driven out of business. The regulations, in effect, induce constrained vertically integrated refiners to cross-subsidize their retailing operations--a practice that would generally be construed as anti-competitive in an unregulated market.

Another regulatory inducement to increased vertical integration lies in the way that increased marketing costs enter the

ceiling price formula. Integrated refiner-marketers, by altering their historic pattern of gasoline distribution toward selling farther downstream, can more than recover increased marketing costs.[1] This can be done because the ceiling price formula causes the higher cost of marketing further downstream to be treated erroneously as a general inflation in marketing costs.

The opportunity to more than recover costs gives constrained refiners a strong incentive to bypass nonaffiliated marketers to whom they would normally sell and to perform the downstream functions themselves. This incentive exists even if the use of independent distribution channels would be more efficient, and the practice is therefore a component of the costly-supply effect.

It might be thought that the allocation regulations would prevent integrated refiners from bypassing their historic customers. However, refiners can manipulate their ceiling price structure to make the purchase of their product unattractive to firms that have allocation rights over it; and the regulations give the constrained refiner a profit incentive to do so. Thus, the allocation regulations cannot be relied upon to offset the generally anticompetitive tendencies of the controls.

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1 For example, selling to final consumers through their retail outlets rather than selling wholesale to independent retailers.

## APPENDIX TO CHAPTER I

## TRADITIONAL ANALYSIS OF PRICE CONTROLS

The typical textbook exposition of a government price ceiling[1] describes a type of control that is very different from that imposed by DOE on petroleum product sellers. As a result, the traditional analysis leads to conclusions that are not necessarily valid for petroleum product regulations. For example, the traditional analysis indicates that binding price controls[2] are necessarily accompanied by a shortage of (i.e., excess demand for) the price-regulated product. This result is so well known that it is often assumed (either explicitly or implicitly) to be applicable in discussions of petroleum product price controls. However, this report shows that the petroleum product regulations will not necessarily cause shortages even when they are binding. The petroleum regulations operate much more like public utility regulations and are able to constrain firms without necessarily inducing shortages.

The traditional analysis can be briefly reviewed using the graph on the left of figure 1-3. In that graph, the industry demand curve is shown by the curve labeled D. In the absence of

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[1] For example, Paul Samuelson, Economics, 8th ed., pp. 370-372.

[2] When applied to an industry made up of profit-maximizing, price-taking firms.

price controls, the industry's supply curve is shown by curve Su, which includes both the solid and the dashed portions.[1] When the government makes it illegal to sell above a specified ceiling price (CP), the industry supply is unchanged for prices below the ceiling price. However, because firms are not allowed to accept bids above CP, there is essentially no supply response for prices above the ceiling. Therefore, with a ceiling price equal to P1, the industry supply is the solid portion of Su labeled Sr. It is effectively truncated at the ceiling price.

In figure 1-3, price P2 would prevail in the absence of the price regulation, and the quantity supplied, v2, would equal the quantity demanded. With the ceiling price at P1, however, only v1 would be supplied, even though the market clearing price at that output would be P3 and excess demand (equal to v3-v1) would exist at the ceiling price.

A determination that this traditional type of price control is binding follows directly from an observation of shortages. It is then implicit that the legal transaction price is lower than it would be in the absence of the controls and that industry output is lower.[2] If the demand curve intersected the regulated supply curve at a price level lower than CP, industry output and price

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1 Curve Su is shown to end near the label "Su", but conceptually it extends to indefinitely higher prices.

2 Assuming away the unlikely case that the unregulated supply curve is perfectly vertical at prices above the ceiling price.

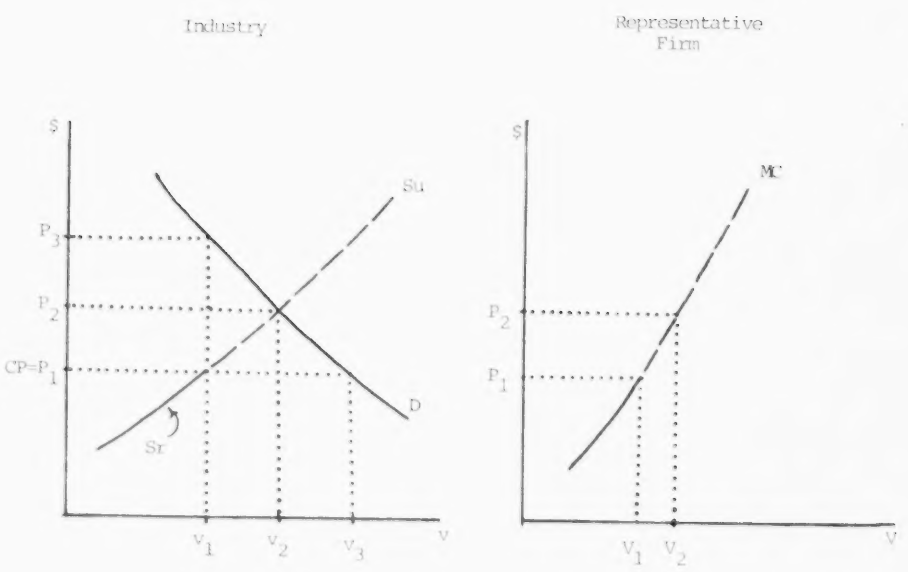
Industry
Representative Firm
$
Su
$P_3$
$P_2$
$CP=P_1$
D
Sr
$V_1$
$V_2$
$V_3$
V
$
MC
$P_2$
$P_1$
$V_1$
$V_2$
V

Figure 1-3

would be the same as if there were no regulation and the regulation would be described as nonbinding.

Underlying the industry supply response is the behavior of individual firms that comprise the industry. The behavior of a representative firm can be illustrated by the right-hand half of figure 1-3. The marginal cost curve of the firm is labeled MC in that graph. The position of the marginal cost curve of the firm is predicated on the firm's attempting to supply any given level of output at the minimum possible cost. Firms maximize profits by producing up to the quantity at which the "cost-minimizing" marginal cost equals marginal revenue.

In the absence of regulation, price-taking firms accept the market clearing price as their marginal revenue and therefore produce the output (e.g., $V_2$) at which the market price equals their marginal cost.[1] If a ceiling price of the type described in the traditional analysis (e.g., $CP=P_1$) is imposed, that ceiling price becomes the marginal revenue of the firm for any market clearing price at or above the ceiling price. Therefore, if demand is such that the market clearing price exceeds the ceiling price, firms simply produce at the output (e.g., $V_1$) at which their marginal cost equals the ceiling price.[2] There is no

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[1] The unregulated industry supply curve is thus the horizontal sum of the marginal cost curves of the firms.

[2] The regulated industry supply curve is still the horizontal sum of the marginal cost curves of individual firms, but it is effectively truncated at the level of the ceiling price.

incentive for the firms to deviate from cost minimization, so the marginal cost of the regulated output lies along the same marginal cost curve that was relevant in the absence of regulation. Each firm in the industry will produce at the same marginal cost; and if the price ceiling is binding, it is binding on all firms.

In summary, the supply response to the traditionally analyzed price regulation is very simple. Given a binding price ceiling, each firm produces the single output at which its cost-minimizing marginal cost is equal to the ceiling price. This single output is invariant with changes in demand.

## CHAPTER II

## THE BASIC MODEL

In this chapter, a very simple model is used to introduce the fundamental nature of the price regulations and to establish some of their key effects. It is shown that a refiner can charge market clearing prices even when the regulations are binding and causing him to price below the level he would select in the absence of the controls. It is also shown that the regulations will cause an inefficient level of output, an inefficient distribution of market shares among refiners, and an inefficient choice of refinery input mix. Finally, it is shown that the regulations may cause prices to be higher than they would be in the absence of the regulations.

### THE MODEL

To abstract from the details of the actual price regulations, the following simplified petroleum industry initially will be assumed.[1] There is a single petroleum product. It is produced by refiners using two inputs, capital and a composite variable input that we will call crude oil. Variable proportions of the inputs can be used to produce any given level of output. Each refiner sells all his output in a single market directly to final consumers.

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[1] The details of the price regulations can be found in U.S. Department of Energy, Federal Energy Guidelines, Para. 13850 (Part 212.83). In the analyses below, a careful attempt was made to reflect the key elements of the regulations as interpreted by DOE as of spring 1980.

Federal price controls on petroleum products essentially establish a nominal "ceiling price" equal to the seller's weighted average May 15, 1973 (base period) price. But the seller is allowed to price above this base period level in order to "pass through" certain increased costs that he incurs. With these simplifying assumptions, a refiner's ceiling price can be written as:[1]

$$[2\text{-}1] \quad Z = P^\circ + (1/V)\left[V\left(\frac{A}{\overline{V}} - \frac{A^\circ}{\overline{V^\circ}}\right) + V\left(\frac{N}{\overline{V}} - \frac{N^\circ}{\overline{V^\circ}}\right)\right]$$

or

$$[2\text{-}2] \quad Z = P^\circ - [(A^\circ+N^\circ)/V^\circ] + [(A+N)/V],$$

where all values are specific to the individual refiner and

°: superscript designating base period values

Z: ceiling price

$P^\circ$: average price in the base period

A: total cost of crude oil (i.e., variable inputs). $A=A(Q)$, $\partial A/\partial Q>0$

Q: the measure of crude oil input

N: total "allowable" cost of capital $N=N(K)$, $\partial N/\partial K>0$

K: the measure of capital input

V: volume of product output. $V=V(Q,K)$, $\partial V/\partial Q>0$, $\partial V/\partial K>0$.

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[1] Provisions for a refiner to charge a higher price to reflect unrecovered costs incurred in earlier periods (i.e., "banked costs") are ignored in the models in this paper, as is the fact that the ceiling price of the current month is predicated on the volume of the current month but the refining costs of the previous month. It is also assumed that the refiner holds no inventories. Certain dynamic aspects of the refiner's behavior may be lost because of these omissions, but it is not believed that the essential conclusions are affected by using a static analysis. These points are discussed in more detail in chapter VII.

In other words, the ceiling price equals the refiner's base period price plus the increase in his average variable cost and the increase in his average "allowable" capital costs. Interest and depreciation are the costs associated with capital that are "allowable" for ceiling price computation. There is no provision for passing through increased equity costs.[1] The return to equity implicit in the price ceiling formula is an absolute dollar amount per unit of output equal, in terms of this model, to

[2-3] $M = P^\circ - \frac{(A^\circ+N^\circ)}{V^\circ}$,

which is roughly the refiner's average accounting profit per unit output in the base period (subsequently referred to as his "base period margin"). Thus, the return to equity is based on output rather than on any measure of capital input.[2]

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[1] It is a well-established proposition that the cost of capital exceeds the cost of long-term debt. Since accounting cost is used for depreciation, there is some possibility that overstated depreciation might equal the sum of economic depreciation and the equity cost of capital not covered by the base period margin. This would, however, be a fortuitous occurrence and is judged improbable. The regulations' restriction on the pass-through of equity capital cost was pointed out in Paul W. MacAvoy (ed.), Federal Energy Administration Regulation, Washington, D.C.: American Enterprise Institute, 1977.

[2] Had the refiner been in long-run equilibrium on the base period date, his base period margin would have theoretically covered his equity cost of capital at that time. Actually, the base period was one of considerable disequilibrium, and refiners probably had widely disparate relationships between their base period margins and their base period equity cost of capital. Since that time, there have been large nominal increases in the cost of capital per unit of refinery output. Therefore, refiners' base period margins cannot be expected to bear any systematic relationship to one another nor to the current equity cost of a refiner's optimal capital stock.

It is perhaps obvious, but also important to emphasize, t the regulations do not confront the refiner with an exogenou determined ceiling price. Rather, the refiner can influence ceiling price by changing his production behavior.

Refiner's Objective

It is assumed that the refiner is a price-taker in the se that he behaves as if his output does not influence the mar price, and it is assumed that there is a market clearing pr above which he cannnot sell. The refiner's objective is to sel input levels, output, and price so as to maximize profit,

[2-4] $\Pi = PV - A - N - R,$

subject to the regulatory constraint and the market constraint his price,

[2-5] $P \leq Z = M + (A+N)/V$

[2-6] $P \leq \overline{P},$

where

$\Pi$: profit

P: selling price chosen by the refiner

$\overline{P}$: market clearing price

R: the refiner's total capital costs that are not allowab for calculating the ceiling price (e.g., the equity co of capital). $R=R(K)$, $\partial R/\partial K>0$.

The relevant Lagrangian function is

[2-7] $L = PV - A - N - R + \lambda_1[M + \frac{A+N}{V} - P] + \lambda_2[\overline{P}-P].$

It is convenient to designate V, K, and P as the refiner's choice variables, recognizing that Q=Q(V,K), and thus A=A(V,K), are implicitly defined by the substitution relationships in the production function.[1] Then, assuming that V, K, and P are greater than zero (i.e., that it is profitable for the refiner to operate), necessary conditions for a profit maximum, given the constraints, are

$$[2\text{-}8]\quad \frac{\partial L}{\partial K} = -\frac{\partial A}{\partial K} - \frac{\partial N}{\partial K} - \frac{\partial R}{\partial K} + \frac{\lambda_1}{V}\left[\frac{\partial A}{\partial K} + \frac{\partial N}{\partial K}\right] = 0$$

$$[2\text{-}9]\quad \frac{\partial L}{\partial V} = P - \frac{\partial A}{\partial V} + \frac{\lambda_1}{V}\left[\frac{\partial A}{\partial V} - \frac{A+N}{V}\right] = 0$$

$$[2\text{-}10]\quad \frac{\partial L}{\partial P} = V - \lambda_1 - \lambda_2 = 0$$

$$[2\text{-}11]\quad \lambda_1\left[\frac{\partial L}{\partial \lambda_1}\right] = \lambda_1\left[M + \frac{A+N}{V} - P\right] = 0$$

$$[2\text{-}12]\quad \lambda_2\left[\frac{\partial L}{\partial \lambda_2}\right] = \lambda_2[\bar{P}-P] = 0,$$

along with [2-5] and [2-6].

---

1 Any two of the variables V, K, and Q could be designated as choice variables. The selection of V and K is for expositional convenience. It allows direct examination of output effects and easy isolation of short-run effects.

While P may not appear to be a choice variable for a price-taker, it must be recognized that even a price taker can select among prices in the range below the market price level. Also, while it might seem that one of the price constraints will always be redundant, equilibrium will frequently be characterized by both constraints binding, and the solution values of the λ's are useful in showing a number of the results.

Long Run and Short Run

This model can be viewed as a long-run model, since capital (K) is a choice variable. Embedded in it is a short-run model that takes K as given. Short-run profit-maximizing conditions are shown by [2-9]-[2-12]. The short-run model is of interest for a number of reasons. First, it yields results concerning pricing behavior, a short-run phenomenon. Second, it is useful for analyzing the immediate consequences of decontrol--the change in prices and output that would occur in the period before capital adjustments could be accomplished.[1] Third, the short-run model is somewhat more tractable. In this simple initial model, the short-run choices can be illustrated graphically.

EQUILIBRIA: MARKET CLEARING PRICES WITH BINDING CONTROLS

An interesting result of this analysis is that refiners constrained by the price regulations are still likely to charge market clearing prices.

To examine the question of market clearance and other implications of the model, it is useful to differentiate the possible profit-maximizing equilibria using the solution values taken on by $\lambda_1$ and $\lambda_2$. The three (comprehensive) categories used are:

Type A: $\lambda_1=0$

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[1] For some decisions, this "short run" may be a very short period of time. Although it takes years to build a major grassroots refinery, significant capital alterations of the "debottlenecking" type can be made in less than a year. Other "capital" changes such as inventory adjustments may be accomplished in even shorter time.

Type B: $\lambda_1>0$, $\lambda_2=0$

Type C: $\lambda_1>0$, $\lambda_2>0$.

Each type of equilibrium is discussed in turn.

Type A: $\lambda_1=0$.

If $\lambda_1=0$ in the profit-maximizing solution, the price controls are not binding. In this case the refiner is unconstrained by the price regulations (subsequently "unconstrained"). It can be seen from [2-10] that the unconstrained refiner will optimally have $\lambda_2>0$ and thus from [2-12] that he will charge the market clearing price. Note that if $\lambda_1$ is set equal to zero, conditions [2-8]-[2-12] are the first order conditions for the refiner if he is unregulated. Thus, when the controls are not binding, the refiner behaves as if he were unregulated.

It is possible that the controls are nonbinding for some refiners. In the short run, being unconstrained requires only that at the volume and input combination that would maximize profits in the absence of controls, the refiner's ceiling price be greater than or equal to the market clearing price. In other words, at the output at which marginal cost equals the market price, the ceiling price is greater than the market price:

[2-13] $\overline{P} = (\partial A/\partial V) \leq M + \frac{A+N}{V}$.

Given the possibility of very high base period margins for some refiners, this equilibrium cannot be rejected.[1]

Type B: $\lambda_1>0, \lambda_2=0$.

If $\lambda_1>0$, and $\lambda_2=0$, it means that the refiner is constrained and would choose to sell at a price below the market clearing level.[2] However, this is not a possible equilibrium in this model if the refiner's base period margin was positive. Note from [2-11] that $\lambda_1>0$ implies $P=M+[(A+N)/V]$; and from [2-10], $\lambda_2=0$ implies $\lambda_1=V$. Substituting for P and $\lambda_1$ in [2-9] yields

[2-14] $M = 0$.

This result has the following interpretation (illustrated in the graphical model, figure 2-1). The expression for $\partial L/\partial V$ in [2-9] can be interpreted as the marginal profitability of increasing

---

1 It might seem that a refiner who is integrated into crude oil production could easily free himself from the effects of the controls by paying his crude oil division a sufficiently high price for crude oil. In that way, he could boost his increased costs enough to make his ceiling price exceed the market price at any given output level. However, artificially increasing in this way the cost of crude oil or any other self-supplied input would be a violation of the regulations. To comply with the regulations, inputs can be valued at no more than their market value. Additionally, in the case of crude oil, price-controlled crude oil must be transferred at its appropriate ceiling price, and DOE publishes maximum price levels that may be claimed for a long list of imported crude-oil types.

2 It does not necessarily follow from $\lambda_2=0$ that the refiner would price below the market clearing price. It is conceivable that P could exactly equal $\bar{P}$ without the relevant constraint being binding. However, this would be an unusual coincidence; and throughout this study it is assumed that nonbinding constrants are not satisfied with equality. This assumption is just an aid to exposition and could be dropped without changing any results.

output in the short run (K constant). When the expression is evaluated with $\lambda_1>0$ and $\lambda_2=0$ (as done to get [2-14]), it indicates that the marginal profitability to the constrained refiner of increases in output is equal to M as long as the refiner's ceiling price remains below the market clearing level. If the refiner's M is greater than zero, he will find it profitable to increase output indefinitely if his ceiling price does not rise to the market clearing level. This result is obtained because the ceiling price formula allows the refiner to increase his ceiling price enough to recover all short-run marginal costs plus a "profit" equal to his base period margin on each additional unit of output.[1]

Type C: $\lambda_1>0$, $\lambda_2>0$.

If condition [2-14] is ruled out, the only remaining solution for the constrained refiner is type C. The refiner, even though the price controls are binding, will find it most profitable to adjust his refinery inputs and outputs so that his ceiling price equals the market clearing price. An implication of this result is that it cannot be concluded that the regulations are nonbinding from the observation that all refiners are charging market clearing prices.

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1 This may seem inconsistent with the usual characterization of the regulations as allowing dollar-for-dollar recoupment of increased costs. The regulations actually do, however, allow changes in profits with changes in sales volume.

OUTPUT AND THE MARKET PRICE LEVEL

In this section it is shown that the qualitative differences between the regulated and unregulated equilibrium output and market price cannot be determined with general functional forms. It is perhaps surprising that the price ceiling regulations can, in theory (and may in fact), cause higher prices if they are binding.

It has been established that market clearing prices are likely even when the price regulations are binding. If that is the case, the equilibrium price follows directly from a determination of industry supply. Since demand is essentially unaffected by the regulations, if refiners, when constrained, will produce more (less) at any given price, it follows that the regulations induce a lower (higher) market price.[1]

In the sections that follow, a graphical analysis is first presented of the supply effects of the regulations in the short run. This is followed by an analysis of long-run supply. It is concluded that the refiner's supply is invariably increased by the regulations in the short run. This definitive result will be shown in chapter III not to be true, once the assumption in this model that the refiner's entire output is subject to price control

---

[1] This point may appear overly obvious. However, it has frequently been concluded, during periods when markets were clearing, that the regulations were causing reduced output (because they had inhibited refinery investment), but that they were also holding prices down.

is relaxed. However, the analysis illuminates the regulatory forces that may cause short-run output to be higher in more realistic models. Even in this simple model, whether a refiner's long-run output is higher or lower due to the regulations will be shown to depend on the specifications of his production function, input supply functions, and the anticipated price for his output. In both the short run and the long run, the regulations will be shown to induce inefficiencies that raise the cost of any given level of output.

SHORT-RUN ANALYSIS

The left quadrant of figure 2-1 shows a refiner's short-run marginal cost (MC) and average total cost (ATC) curves. (Curve MC' can be ignored for the moment.) These curves have their traditional meanings. Since the amount of capital is fixed in the short run, the refiner's output is determined strictly by the quantity of the variable input applied to the given capital stock. Therefore, it is assumed that in the short run the refiner's cost curves are the same with or without regulation.

The regulated refiner's ceiling price at each output can be shown by curve CP. The vertical distance between ATC and CP would be

$$[2\text{-}15] \quad M + \frac{(A+N)}{V} - \frac{(A+N+R)}{V} = M - (R/V).$$

FIGURE 7-1

In the absence of regulation, the refiner's supply curve would be his marginal cost curve. Thus, if faced with a market clearing price such as $\bar{P}_1$, the unregulated refiner would produce $V_1$ and would, of course, sell it at price $\bar{P}_1$. This output choice would maximize his profits.

The refiner's profit-maximizing calculus is altered by the price regulations. It can be shown that for any price above $\bar{P}_o$ the regulated refiner's supply curve is the CP curve.[1] This is demonstrated as follows. If the regulated refiner is faced with a market clearing price of $\bar{P}_1$ and produces $V_1$, he can sell the output at a price of only $Z_1$ (the level of the CP curve at $V_1$). His profit at that output would be $V_1[M-(R/V_1)]$ or $MV_1-R$. If the regulated refiner expands output above $V_1$, he will increase his profit by M for each additional unit that he refines, as long as he can collect his ceiling price.[2] At output $V_2$, for example, the refiner could still collect the ceiling price because it would just equal the assumed market clearing price, $\bar{P}_1$; and his profit would be $V_2[M-(R/V_2)]$ or $MV_2 -R$.

---

1 At prices below $P_o$, the refiner is unconstrained. At those prices, the output that the refiner would choose absent the price regulations, to maximize profits, results in a ceiling price above the market price.

2 As discussed following [2-14] above.

If the refiner expanded output beyond $V_2$, his ceiling price would continue to rise; but he could sell only at the market clearing price $\bar{P}_1$. For each additional unit refined above $V_2$, therefore, his profit would be reduced by the difference between $\bar{P}_1$ and MC.[1]

Output $V_2$ is thus the profit-maximizing output for the regulated refiner facing a market clearing price of $\bar{P}_1$. The preceding logic can be repeated for other assumed market prices to confirm that curve CP will be the supply curve for the constrained, regulated refiner.

Figure 2-1 illustrates three results. First, market clearing prices can prevail even with binding price regulation. Second, the refiner produces to a point at which his marginal production cost exceeds his selling price (e.g., at $V_2$ marginal cost is

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1 With a market price of $\bar{P}_1$, the refiner's marginal revenue is equal to $\bar{P}_1$ up to output $V_o$ (at which he becomes constrained); marginal revenue is equal to marginal cost plus M for outputs between $V_o$ and $V_2$; and marginal revenue drops back to $\bar{P}_1$ for outputs greater than $V_2$.

$MC_2 > P_1$).[1] And third, the regulations, when binding, increase output in the short run[2] at any given price.

Taking the first and second results in conjunction--market clearing prices less than the refiner's marginal cost--implies two types of inefficiency. First, it implies an inefficiently high allocation of resources to the production of petroleum products by each constrained refiner. When marginal cost exceeds price, the value to consumers of marginal units of output is less than the resource cost of those units.[3] Second, since industry equilibrium will involve constrained refiners equating their ceiling prices

---

1 This can also be seen from [2-9]. When the refiner is constrained and at the market clearing price, $P=\overline{P}$, which substituted into [2-9], yields:

$$\overline{P} + \frac{\lambda_1}{\overline{V}}\left[\frac{\partial A}{\partial \overline{V}} - \frac{A+N}{\overline{V}}\right] = \frac{\partial A}{\partial \overline{V}}$$

as a profit-maximizing equilibrium condition. Since $\lambda_1 > 0$ for the constrained refiner, his price ($\overline{P}$) will be lower than his marginal cost ($\partial A/\partial V$) in equilibrium, if the term in brackets is positive. The term in brackets must be positive in this simple model, if the refiner is constrained. If the term in brackets were negative, it would imply that condition [2-13] had been satisfied and that the controls were nonbinding.

2 This is implicit in the preceding footnote. The refiner, if unregulated, would have marginal cost equal to price in equilibrium. Therefore, the regulations induce a higher marginal cost for any given price. Since the refiner's cost function is the same in the short run with or without regulation, the higher marginal cost implies a higher output.

3 This inefficiency is compounded when it is recognized that because of both crude oil price controls and foreign policy implications, the cost to the refiner of the major variable input, crude oil, probably understates its true social cost.

rather than their marginal costs to the market clearing price, distribution of output among refiners will be inefficient. Getting the greatest output from the resources consumed by the industry requires refiners to equate their marginal costs.[1] In summary, the regulations cause too many resources to be devoted to petroleum refining, and given the total resource commitment, regulations cause too little output by inducing inefficient market shares among refiners.

The first and third results in conjunction--market clearing prices and greater output at any given price when the refiner is constrained by the regulations--imply that in the short run, the

---

1 Equal ceiling prices for constrained refiners will not imply equal marginal cost for all refiners in the market. First, some refiners are likely to be unconstrained and to be equating their marginal cost to the market price. Second, refiners have different production functions; thus, each may have a different marginal cost corresponding to any common average allowable cost. Third, even if each refiner has the same production function, this would imply equal marginal costs only if each has the same base period margin. In fact, base period margins probably vary across refiners because of the industry disequilibrium that prevailed on the base date. In addition, the Phase III price controls (which were in effect on May 15, 1973) caused large disparities in base period margins because of their varying effect on different refiners' prices. The smallest refiners (fewer than 60 employees and $50 million annual sales) were exempt from Phase III, while a group of larger firms were subject to voluntary restrictions on price increases. The 24 largest firms (over $50 million annual sales) were subject to "Special Rule Number 1." Special Rule Number 1 was mandatory and permitted price increases above the January 11, 1973 level by a weighted average of only one percent (or 1.5 percent with cost justification) without prior approval. Any increases greater than 1.5 percent required prenotification, which involved significant delays, and were subject to profit margin limits when approved. The effects of Phase III varied even among firms subject to the same type of controls because the prices permitted depended on firm-specific variables.

regulations cause higher industry output and a lower price. This is illustrated by the right-hand quadrant of figure 2-1. In that graph, curve Su is the short-run industry supply curve in the absence of regulation. It is the horizontal sum of the individual refiners' MC curves. $S_r$ is the supply curve with regulation--the horizontal sum of individual refiner's CP curves. (Curve Su' can be ignored for the moment.) If curve D is the relevant industry demand, the regulated equilibrium price would be Pr and the unregulated equilibrium price Pu. The regulated output would be the same as the unregulated output only if demand were such that no refiners were constrained at the market clearing price.

LONG-RUN ANALYSIS: COSTLY INPUT MIX

The refiner is unconstrained in the long run if, given the expected price at the time in the future[1] for which capital is being selected, he would select the same capital stock to maximize

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1 The models of this paper, due to their steady-state nature, do not capture many facets of capital choice. Capital is generally durable and lumpy, and investments often irreversible. Actual capital choice is based on expected conditions over the life of the capital asset rather than at a point in time. The implications of the model concerning investment decisions might be questioned on these grounds. For example, if the refiner expected to be regulated (or constrained) for only a portion of the life of the typical asset (a probable case), many investments would be made even though they would prove unprofitable during the period the refiner is constrained. However, the qualitative predictions of the model are defensible because most refiners would probably also have marginal investments that would be delayed or rejected if the refiners expected to be constrained during a portion of the lives of the assets.

profits, whether regulated or unregulated.[1] In other words, he i unconstrained if the optimal solution of [2-8]-[2-12] resulted i $\lambda_1=0$. If $\lambda_1>0$, he is constrained.

It is assumed that petroleum refiners can produce a give output with different mixes of crude oil and capital.[2] In a unregulated market, a profit-maximizing firm will select the inpu mix that minimizes total cost, given output. Condition [2-8] indicates that the regulated refiner will not select the cost-minimizing input mix.

Condition [2-8] can be interpreted as describing the refiner's profit-maximizing location in Q,K space on the isoquant for any given V. Substituting (from [2-10]) $\lambda_1=V-\lambda_2$ into [2-8], it can be rewritten

$$[2\text{-}16] \quad -(\lambda_2/V)(\partial A/\partial K) = (\lambda_2/V)(\partial N/\partial K) + (\partial R/\partial K).$$

First note that if the refiner is not constrained by the regula-tions ($\lambda_1=0$ and thus $\lambda_2=V$) or if all cost increases could be passed through ($\partial R/\partial K = 0$), the refiner's optimal input mix choice would be described by

---

1 Even if a refiner is unconstrained in the long run, his choice may be affected by the regulations. He may perceive that they will affect other refiners and, therefore, future prices.

2 The substitution possibilities may be more easily concep-tualized if the crude oil input metric Q and the output metric V are viewed as having a quality dimension. Thus, getting the same volume and quality of output with a higher Q and lower K would be achieved by using a higher quality crude oil that would yield the same mix of gasoline and other products with the use of less proc-essing equipment. It should also be recognized that Q could encompass variable inputs other than crude oil.

[2-17] $-(\partial A/\partial K) = (\partial N/\partial K) + (\partial R/\partial K)$.

Condition [2-17] describes the cost-minimizing point on a normal isoquant. It is the point at which, as capital (K) is substituted for crude oil (Q) while maintaining the specified output, the marginal rate of decrease in crude oil cost (A) falls to equal the marginal rate of increase in the cost of capital (N+R).

If, however, the refiner is constrained by the regulations ($\lambda 1>0$) and some portion of capital cost increases cannot be passed through ($\partial R/\partial K>0$), condition [2-16] implies that the profit-maximizing input combination would be at a point on the isoquant at which

[2-18] $-(\partial A/\partial K) > (\partial N/\partial K) + (\partial R/\partial K)$.

Condition [2-18] describes a K/Q ratio that is lower than the cost-minimizing K/Q ratio. Therefore, if there are marginal non-allowable capital costs as assumed, whatever output the refiner selects will be produced in long-run equilibrium with an inefficiently low amount of capital.[1]

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1 Since there is substitutability between equity capital and debt capital, it would be expected that the inability to pass through equity cost increases would also induce an inefficiently high debt-equity ratio. However, as long as the substitution of debt for equity is not costless, the substitution away from capital toward noncapital inputs will also be profitable. For a diversified firm, increasing the debt-equity ratio from its most efficient level will be made less attractive by the fact that only a pro rata share (related in some way to the relative importance of the firm's refining activities) of the increased interest cost can be passed through in the ceiling price, while the higher risk to the firm's owners caused by increasing the debt-equity ratio will raise the cost of equity capital for all of the firm's operations.

LONG-RUN COMPARATIVE OUTPUT AND PRICE

In the long run, capital can be varied; and in the short run, the level of capital is determined by capital choices in earlier periods. If capital adjustments are allowed, the comparative static analysis depicted in figure 2-1 may change as follows. The cost curves in figure 2-1 are predicated on a certain level of capital. If the refiner had invested in more capital in the absence of regulation, his marginal cost curve would have been farther to the right and might have been shown by MC'. In that case, CP would be viewed as the refiner's supply curve resulting from regulation and MC' as the supply curve in the absence of regulation. Now, the refiner's comparative output is indeterminate if the market clearing price is not known. At prices above $\bar{P}_2$ he would produce more due to the regulations; at prices below $\bar{P}_2$, less.

Looking at the right quadrant of figure 2-1, Sr could still represent the industry supply resulting from regulation, while Su' (the horizontal sum of MC' curves) represented the industry supply in the absence of regulation. Then, if curve D were the demand curve, the equilibrium price with regulation (Pr) would be higher than the price (Pu') that would have prevailed in the absence of regulation. This comparative price result would not hold for all demand curves, however, because at some higher levels of demand, curve Su' implies a lower supply than Sr.

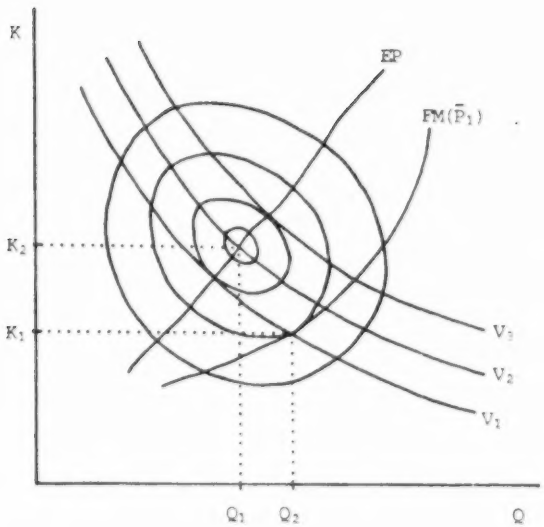
The capital choice and the long-run output for a given refiner are implicit in conditions [2-8] through [2-12]; but short of specifying all of the relevant parameters and solving the equations simultaneously, there appears to be no way of ascertaining the comparative choices with and without regulation.

Elements of the comparative capital choices and long-run output choices of the regulated and unregulated refiner can be illustrated with figure 2-2. Capital input is measured on the vertical axis and crude oil input on the horizontal axis. The downward sloping lines are conventional isoquants with those farther from the origin showing higher volumes. The refiner's isoquant map simply shows the refiner's production possibilities and is assumed to be the same whether he is regulated or not.

The unregulated refiner would select his input mix at any given output to minimize production cost. The locus of these cost-minimizing points might be shown by curve EP. Given an expected market price, iso-profit contours can be plotted and might be shown as the concentric circles--smaller circles showing the input/output choices that yield higher profits. The unregulated refiner would locate at the point of highest profit. That point lies on EP and is shown at output $V_2$ employing $K_2$ units of capital and $Q_1$ of crude oil.

The EP curve implicitly specifies the unregulated refiner's use of capital and crude oil as a function of volume. From it, given input prices, the long-run cost of capital and crude could

FIGURE 2-2



be determined as a function of volume alone (i.e., $A=\hat{A}(V)$, $N=\hat{N}(V)$ and $R=\hat{R}(V)$). A long-run profit function could be written using these cost functions.

[2-19] $\hat{\Pi} = \bar{P}V - \hat{A} - \hat{N} - \hat{R}$

As the unregulated refiner expanded volume along the EP curve, he would encounter the peak of the profit hill at the point where price equals long-run marginal cost

[2-20] $d\hat{\Pi}/dV = \bar{P}-(d\hat{A}/dV)-(d\hat{N}/dV)-(d\hat{R}/dV) = 0.$

From [2-16] it is known that the constrained regulated refiner will use a lower than cost-minimizing K/Q ratio and will thus locate to the right of EP. It is also known that the constrained refiner will equate his ceiling price to the market price. Therefore, the constrained refiner's profit-maximizing input combination, given an expected market clearing price and given an output, can be found by moving to the right along the relevant isoquant from the EP intersection until the allowable input costs rise to cause a ceiling price equal to the market clearing price.[1] One such point can be identified on each isoquant and the locus might be traced out by a "factor mix" curve

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1 The allowable input cost rises as K is reduced from the EP intersection, but it is the concurrent reduction in nonallowable costs that makes the move profitable. If the ceiling price calculation already exceeds the market price at the EP intersection on a particular isoquant, the regulations are not binding on the refiner at that price and output; and the EP intersection gives his optimal factor mix.

such as that labeled FM($\bar{P}_1$). The $\bar{P}_1$ signifies that the curve is appropriate only for a single market price. For a higher market price, the point on each isoquant at which the ceiling price equaled the market price would be farther to the right.

The constrained refiner's profit-maximizing input mix and output would be determined at the point where the FM curve reaches the highest profit contour--shown in figure 2-2 at output $V_1$ using $K_1$ and $Q_2$. In the case illustrated, the refiner's long-run volume choice is lower than if he were unregulated, but that would not necessarily be the case.

Given a market price, FM implicitly defines the functions $K=\tilde{K}(V)$ and $Q=\tilde{Q}(V)$, and given input prices, indirectly defines the functions $A=\tilde{A}(V)$, $N=\tilde{N}(V)$, and $R=\tilde{R}(V)$. The constrained refiner's profit could be written using these ersatz long-run cost functions, as

$$[2\text{-}21] \quad \tilde{\Pi} = [M + \frac{\tilde{A}+\tilde{N}}{V}]V - \tilde{A} - \tilde{N} - \tilde{R}.$$

The market price constraint is implicit in the "cost" functions as they have been constructed. The profit-maximizing point would be reached, as the refiner moved along FM, at the point where

$$[2\text{-}22] \quad d\tilde{\Pi}/dV = M - (d\tilde{R}/dV) = 0.$$

In other words, it is the point at which his marginal nonallowable costs rise to equal his base period margin. This point bears no general relationship in the K or V dimension to the point selected if the refiner is unregulated.[1]

---

[1] If constrained refiners all have constant long-run cost functions, the inefficient choice of input mix induced by the regulations would unambiguously imply a higher industry price in the long run due to the regulations. However, if some refiners have long-run marginal costs that exceed their long-run average costs, the regulations may result in higher output and a lower price. In this regard, it is interesting to note that the crude oil price regulations generally cause individual refiners to have a rising average cost of crude oil.

## CHAPTER III

## PARTIAL DECONTROL, RETAILING, AND PURCHASES OF GASOLINE

The Energy Policy and Conservation Act of December 1975 allowed DOE to exempt petroleum products from price regulation subject to a veto by majority vote of either house of Congress. In response, DOE has decontrolled most petroleum products other than motor gasoline.

To show the effects of partial decontrol on the results of the preceding analysis, it is now assumed that there are two jointly produced products, one controlled and one uncontrolled. The controlled product shall be referred to as "gasoline." In the analysis below, the model is also structured to allow examination of the effects of the price controls on more typical refiners who not only refine crude but are also integrated into gasoline marketing. Another important addition to the model is that refiners may buy gasoline from other sources of supply in order to supplement their own refinery outputs.

Three major results follow from the analysis of this expanded model. The first is that the price controls will, in the short run, always induce the constrained integrated refiner to choose a higher level of retail sales than he would in the absence of controls. That is, such refiners will always, in the short run, increase their marketing operations to the point that marginal marketing cost is greater than the marketing margin. The second result is that in contrast to the results of the model in chapter

II, the refinery output volume of the constrained refiner in thi model, even in the short run, may be either greater or less unde the controls than in the absence of controls. The third result i that constrained refiners are likely to produce an inefficien output mix. These results are utilized to show that: (1) Th controls serve to increase the cost of marketing any given volum of gasoline. (2) The controls have an anticompetitive impact o the gasoline marketing industry. (3) The controls do not neces sarily serve to reduce gasoline prices even in the short run.

A description of the model follows.

THE MODEL

Gasoline marketing is added to the preceding model in a stylized manner to simplify the analysis.[1] It is assumed that the refiner makes all gasoline sales at retail, that retail gasoline is homogeneous, that there are no economies or diseconomies of operating multiple retail outlets, and that the refiner's retail outlets are all supplied directly, located in the same retail market, sell only gasoline at a single price, and each outlet has the same cost function.

Purchases of gasoline from other sources also enter the model in a simple manner. It is assumed that the refiner purchases only

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[1] This model maintains the assumptions of chapter II that refiners are price-takers, that they carry no inventories either of crude oil or of refined product, that they have no banked costs and that there is no time lag in the cost pass-through.

gasoline, that the price of purchased gasoline ($P_p$) is exogenous, and that there are no transaction costs. When retailing and purchases of gasoline are incorporated into the preceding model, the refiner's profits can be written as:

[3-1] $\Pi = Pm(GVr+Vp) + Pu(1-G)Vr - Ar-Nr-Rr - Am-Nm-Rm - PpVp,$

subject to:

[3-2] $Pm \leq Zm$

[3-3] $Pm \leq \bar{P}m,$

where, as before, all values are specific to the individual refiner and

r: subscript added to previously defined terms to designate that they are relevant to refining rather than marketing

Pm: retail selling price of gasoline chosen by the refiner

G: volumetric fraction of gasoline in the refiner's total output. $0<G<1$. $G=G(Qr,Kr,Vr)$. GVr is the volume of gasoline refined.

Vp: volume of gasoline purchased for resale

Pp: average price of gasoline purchased by the refiner

Pu: market price of the uncontrolled products

Am: variable costs of retailing, excluding the cost of gasoline. $Am=Am(Qm)$, $\partial Am/\partial Qm>0$

Qm: the measure of variable inputs to retailing other than gasoline

Nm: allowable capital costs of marketing. $Nm=Nm(Km)$, $\partial Nm/\partial Km>0$.

Rm: nonallowable capital costs of marketing. $Rm=Rm(Km)$, $\partial Rm/\partial Km>0$.

Km: measure of capital input to marketing.

GVr+Vp=Vm: total volume of gasoline sold by the refiner. $\partial Vm/\partial Vr=G$, $\partial Vm/\partial Vp=1$.

Zm: ceiling price of gasoline (to be defined below).

$\overline{Pm}$: market clearing price for retail gasoline.

The refiner's ceiling price in this model can be written

$$[3\text{-}4]\quad Zm = Pm^\circ + [GVr[(\frac{Ar+Nr}{Vr})-(\frac{Ar^\circ+Nr^\circ}{Vr^\circ})] + Vp(Pp-Pp^\circ)]\frac{1}{GVr+Vp} + \frac{Am+Nm}{Vm} - \frac{Am^\circ+Nm^\circ}{Vm^\circ};$$

or, defining some notation to condense the terms,

$$Xr = \frac{Ar+Nr}{Vr}, \qquad Xm = \frac{Am+Nm}{Vm},$$

$$Xr^\circ = \frac{Ar^\circ+Nr^\circ}{Vr^\circ}, \qquad Xm^\circ = \frac{Am^\circ+Nm^\circ}{Vm^\circ},$$

the ceiling price can be written

$$[3\text{-}5]\quad Zm = Pm^\circ + [GVr(Xr-Xr^\circ) + Vp(Pp-Pp^\circ)][\frac{1}{GVr+Vp}] + Xm-Xm^\circ.$$

As before, the refiner's ceiling price is determined by adding to his base period price--in this case his average retail price for gasoline on May 15, 1973 ($Pm^\circ$)--increases in his average allowable cost for the controlled product.

Note an important point: the increased average refinery costs that can be attributed to gasoline, $GVr(Xr-Xr^\circ)$, are only a fraction of the increased average cost of refining. That fraction is equal in this model to the volumetric fraction of gasoline in

the refiner's output (G).[1] Also note that these average refining costs are those for refining all products, not gasoline specifically.

In addition to refining costs, the firm is permitted to recoup all the increased average cost of purchased gasoline. This is computed as the difference between the current and base period average price weighted by current purchase volume. In other words, Vp(Pp-Pp°). Finally, the refiner is permitted to recoup his increased "marketing nonproduct costs," which are computed by taking the difference between the current and base period average allowable marketing nonproduct cost, Xm-Xm°.

The relevant Lagrangian function for this refiner is

[3-6] $L = \Pi + \lambda_1(Zm-Pm) + \lambda_2(\overline{P}m-Pm)$.

It is convenient to designate Kr, Km, Vr, Vp, G, and Pm as the refiner's choice variables. To evaluate the Lagrangian function with respect to these choice variables, it must be recognized that the following functional relationships are implicitly defined by the substitution possibilities in the production function: Or =Or(Vr,Kr,G), which implies Ar =Ar(Vr,Kr,G); and Om =Om(Vm,Km), which implies Am =Am(Vm,Km) where Vm =(GVr+Vp).

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1 The "tilt" regulations, instituted in March 1979, allow a greater than proportional share of total cost to be attributed to gasoline production in the computation of gasoline ceiling prices. Incorporating those regulations alters this analysis somewhat, but does not change the basic results. "Tilt" is examined in the next chapter.

Necessary conditions for profit maximization are (assuming that Vr, Kr, Km, G, Pm, and Vp are all greater than zero):

$$[3\text{-}7]\quad \frac{\partial L}{\partial Kr} = -\frac{\partial Ar}{\partial Kr} - \frac{\partial Nr}{\partial Kr} - \frac{\partial Rr}{\partial Kr} + \frac{G\lambda_1}{GVr+Vp}\left(\frac{\partial Ar}{\partial Kr} + \frac{\partial Nr}{\partial Kr}\right) = 0$$

$$[3\text{-}8]\quad \frac{\partial L}{\partial Km} = -\frac{\partial Am}{\partial Km} - \frac{\partial Nm}{\partial Km} - \frac{\partial Rm}{\partial Km} + \frac{\lambda_1}{GVr+Vp}\left(\frac{\partial Am}{\partial Km} + \frac{\partial Nm}{\partial Km}\right) = 0$$

$$[3\text{-}9]\quad \frac{\partial L}{\partial G} = Vr(Pm-Pu) - \frac{\partial Ar}{\partial G} - \frac{\partial Am}{\partial G} + \lambda_1\left(\frac{\partial Zm}{\partial G}\right) = 0$$

$$[3\text{-}10]\quad \frac{\partial L}{\partial Vr} = GPm + (1-G)Pu - \frac{\partial Ar}{\partial Vr} - G\frac{\partial Am}{\partial Vm} + \lambda_1\left(\frac{\partial Zm}{\partial Vr}\right) = 0$$

$$[3\text{-}11]\quad \frac{\partial L}{\partial Vp} = Pm - Pp - \frac{\partial Am}{\partial Vm} + \lambda_1\left(\frac{\partial Zm}{\partial Vp}\right) = 0$$

$$[3\text{-}12]\quad \frac{\partial L}{\partial Pm} = GVr + Vp - \lambda_1 - \lambda_2 = 0$$

$$[3\text{-}13]\quad \lambda_1\left[\frac{\partial L}{\partial \lambda_1}\right] = \lambda_1[Zm - Pm] = 0$$

$$[3\text{-}14]\quad \lambda_2\left[\frac{\partial L}{\partial \lambda_2}\right] = \lambda_2[\bar{P}m - Pm] = 0$$

along with conditions [3-2] and [3-3].

The progression of the analysis will be as follows. First the implications of the model concerning short-run behavior will be examined. The short-run model (K constant) embedded in this essentially long-run model consists of equations [3-9]-[3-14] along with [3-2] and [3-3]. The bulk of the analysis will concern

the short run because the long-run results are similar to those in the previous model and even less tractable using general functions.

After discussing the possible equilibria of the model in the context of pricing behavior, the short-run effect of the regulations on output, efficiency, and competition are examined--first for retailing and then for refining. Then long-run efficiency and output are discussed, drawing comparisons with the previous results. In analyzing both the short run and the long run, to simplify the exposition, it is assumed that G is constant. At the end of this chapter the consequences of allowing G to be varied are discussed.

EQUILIBRIA AND MARKET CLEARANCE

As before, it is useful to categorize the possible equilibria as

Type A: $\lambda_1=0$

Type B: $\lambda_1>0$, $\lambda_2=0$

Type C: $\lambda_1>0$, $\lambda_2>0$

and to discuss them in turn.

Type A: $\lambda_1=0$.

Again, $\lambda_1=0$ implies that the price regulations are not binding. It can be seen from [3-12] that if $\lambda_1=0$, the refiner will have $\lambda_2>0$; and thus from [3-14], that he will charge the market clearing price.

It can also be seen that if $\lambda_1$ is set equal to zero, the conditions [3-7]-[3-14] become the profit-maximizing conditions

for the refiner if he were unregulated. (This observation proves useful for subsequent analysis.) Thus, when the refiner is unconstrained, he behaves in all respects as if he were unregulated.

A regulated refiner will be unconstrained in the short run (i.e., $\lambda_1=0$ for the optimal solution of [3-10]-[3-13]) only if at his free market output his ceiling price would equal or exceed the market price. By manipulation of [3-5], this condition can be shown equivalent to

[3-15] $Vm[(Pm^{\circ}-Pp^{\circ}-Xm^{\circ})-(\overline{P}m-Pp-Xm)] + GVr[(Pp^{\circ}-Xr^{\circ})-(Pp-Xr)] > 0.$

If the base period variables had reflected long-run equilibrium in the base period, condition [3-15] could be interpreted as requiring that the equilibrium return to equity per unit of output has fallen between the base period and the current period. Although the equilibrium return to marketing equity per unit of output may have fallen slightly because of increases in the equilibrium level of volume per outlet, the increase in capital cost per unit of output in refining should dominate and cause the normal firm to be constrained by the controls. As noted in chapter II, however, the base period was not an equilibrium period, and $Pm^{\circ}$, $Pp^{\circ}$, and $Xr^{\circ}$ may vary widely across firms. Therefore, it is to be anticipated that there will exist some refiners with unusual base period prices and costs who will not be constrained.

Type B: $\lambda_1>0$, $\lambda_2=0$.

In this type of equilibrium the refiner is constrained but does not find it profitable to equate his ceiling price to the market price. While this type of equilibrium could in principle occur, it is believed that the values of certain variables are normally such that it will not.

To show this, note that if $\lambda_1>0$, condition [3-11] can be shown equivalent to[1]

[3-16] $\partial L/\partial Vp = Pm^\circ - Pp^\circ - Xm^\circ - \lambda_2(\partial Zm/\partial Vp) = 0$

Then, if $\lambda_2=0$, [3-16] implies that

[3-17] $Pm^\circ - Pp^\circ - Xm^\circ$

is equal to zero.

Since $Pm^\circ - Pp^\circ - Xm^\circ > 0$ simply implies that the marketing of purchased gasoline earned an accounting profit in the base period, it seems quite reasonable to assume that few if any refiners will be described by the condition $Pm^\circ - Pp^\circ - Xm^\circ = 0$. Therefore, the type B equilibria is rejected because it is generally irrelevant, and it is concluded that a constrained refiner will usually not find it

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[1] Condition [3-16] is derived from [3-11] by deriving $\partial Zm/\partial Vp = (1/Vm)\,[Pp - Pp^\circ + (\partial Am/\partial Vm) - Xm^\circ + Pm^\circ - Zm]$, substituting for $\lambda_1$ from [3-12], and substituting Zm for Pm (see [3-13]). The result can be reduced to that shown in [3-16].

profitable to operate with his ceiling price below the market clearing level.

The explanation for this result is that the regulations allow the refiner to increase his gasoline ceiling price sufficiently to recover all short-run marginal costs of purchasing and marketing gasoline. In addition, he is permitted a profit margin on each unit resold equal to his "base period reselling margin" shown in [3-17]. If his base period reselling margin was positive and his ceiling price for gasoline is below the market clearing level, he will always find it profitable to purchase more gasoline and resell it, boosting his ceiling price to cover the additional costs and earning additional profit on each unit resold.

The expression in [3-17] can be interpreted as the marginal profitability of reselling purchased gasoline for a constrained refiner whose ceiling price is below the market clearing level.[1] It is noteworthy that it contains only base period values. It is independent of any of the refiner's other choice variables and it is independent of the price to the refiner of the gasoline that he purchases.

Type C: $\lambda_1>0$, $\lambda_2>0$.

This type of potential equilibrium describes the case in which the refiner is constrained by the ceiling price but finds

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1 Recall that in the preceding model the type B equilibria was rejected by concluding that the marginal profitability of increasing refinery volume was always positive for the constrained refiner when his ceiling price was below the market price. As shown below in the discussion of short-run refinery output, this is no longer the case, due to partial decontrol.

it profitable to equate his ceiling price to the market price. If $Pm^{\circ}-Pp^{\circ}-Xm^{\circ}<0$ is ruled out, this can be identified as the relevant description of equilibrium for the constrained refiner.

The question arises, If all constrained refiners find themselves with gasoline ceiling prices below the market clearing level, from whom do they purchase gasoline to achieve the equilibrium in which their ceiling price rises to the market clearing level? There are two possibilities; they can purchase from unconstrained domestic refiners or from unregulated foreign refiners. The constrained refiners would seek out the least expensive sources of gasoline (in order to achieve maximum sales volume and thus earn the allowed margin on the maximum number of units) but would find it profitable to purchase at any price rather than remaining in the situation in which their ceiling prices were below the market clearing level.[1]

SHORT-RUN ANALYSIS OF RETAILING: VOLUME, EFFICIENCY, AND COMPETITION

It is useful to address the question of whether a constrained refiner, given Pm and Pu, will have a higher or lower retailing volume (GVr+Vp) in the short run than he would in the absence of

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[1] DOE has argued that the volume of foreign product available for import may be inadequate to raise domestic ceiling prices appreciably. (See U.S. DOE, Final Environmental Impact Statement: Motor Gasoline Deregulation and the Gasoline Tilt, January 1, 1979, Vol. I, p. III-18.) However, even small volumes can have a significant effect if they have high enough prices. If constrained firms compete for the available imports, they will find it profitable to bid the price of imports high enough to cause all the constrained resellers' ceiling prices to reach the market clearing level.

regulation. It is shown below that the answer to this questi depends upon the price (Pp) at which he can purchase gasoline f resale. Since Pp may be different with and without regulation, will not be possible to determine in general whether the absolu volume of retailing will be higher or lower with controls. Ho ever, it will be shown that the regulations induce the constrain refiner to operate his retail outlets at an inefficiently hi volume given any Pp. It will also be shown that this regulato effect can have adverse consequences for efficient nonintegrate independent retailers who compete with the constrained integrat refiners whose behavior is modeled.

Volume

As remarked previously, if $\lambda_1$ is set equal to zero, cond tions [3-7]-[3-14] are the first order conditions for the refin if he were unregulated (or unconstrained). From [3-11], ther fore,[1]

[3-18] $(\partial L/\partial Vp)^* = \overline{Pm} - Pp - (\partial Am/\partial Vm)^* = 0.$

is a profit-maximizing condition for the refiner if he we unregulated. The asterisk is used as a reminder that this is t condition for an unregulated (or unconstrained) refiner.

It was established in the examination of the possible equil bria that for the normal constrained refiner $\lambda_2>0$. From [3-14],

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[1] From [3-12], $\lambda_1=0$ implies $\lambda_2>0$, and from [3-14], $\lambda_2>0$ impli $Pm=\overline{Pm}$.

again, $\lambda_2 > 0$ implies $Pm = \bar{P}m$. Therefore, the condition equivalent to [3-18] for the constrained refiner is (from [3-11])

[3-19] $\partial L/\partial Vp = \bar{P}m - Pp - (\partial Am/\partial Vm) + \lambda_1(\partial Zm/\partial Vp) = 0.$

Since it is assumed that the refiner's short-run (Km constant) retailing cost function is the same with or without regulation, if the value of $(\partial Am/\partial Vm)$ in the regulated equilibrium is higher than that in the unregulated equilibrium it can be concluded that the equilibrium retailing volume of the refiner is higher with the regulations than without.

It can be shown, if $\bar{P}m$ and Pp are the same in [3-18] and [3-19], that $(\partial Am/\partial Vm)$ is higher in [3-19]. That is, given the same $\bar{P}m$ and Pp in each case, the refiner would incur a higher marginal retailing cost (and by implication have a higher retail volume) in the short run if he is constrained by the regulations than if he is unregulated. This is demonstrated as follows. Comparing [3-18] and [3-19], it can be seen that if $\bar{P}m$ and Pp are the same, $(\partial Am/\partial Vm)$ must be higher in [3-19] if $\lambda_1(\partial Zm/\partial Vp)$ is greater than zero. Since $\lambda_1 > 0$ for the constrained refiner, it must only be shown that $(\partial Zm/\partial Vp) > 0$. Examine the equilibrium condition for the constrained refiner presented above at [3-16]:

[3-20] $\partial L/\partial Vp = Pm^\circ - Pp^\circ - Xm^\circ - \lambda_2(\partial Zm/\partial Vp) = 0.$

Since it is expected that $Pm^\circ - Pp^\circ - Xm^\circ > 0$, and since if that is the case $\lambda_2 > 0$, equation [3-20] requires that $(\partial Zm/\partial Vp) > 0$ for the constrained refiner in equilibrium.

If it could be presumed that the regulations did not affect Pp, or if it could be presumed that the direction of any regulatory effect was to decrease Pp, then it could be concluded that the supply of products at retail was unambiguously higher in the short run (and thus the equilibrium retail market price unambiguously lower) with binding regulations than without. This conclusion cannot be drawn, because Pp is a function of the refinery output of the industry, and it is shown in the following section that the regulations may cause refinery volume to be reduced in the short run. This would cause Pp to be higher than it would be in the absence of regulation.

Retailing Efficiency

The conclusion can be drawn from [3-19] that the regulations result in an inefficient distribution of retailing activity among the retailers in a given market. Assuming that all retailers in a given market face the same Pp and $\overline{Pm}$ and that they provide a homogeneous service, retailing any given quantity of gasoline at minimum cost requires that market shares be distributed among retailers in such a way that they all have the same marginal cost of providing the retailing services ($\partial Am/\partial Vm$). From [3-18] it can be seen that this would be the case in the unregulated equilibrium, since each retailer would equate his marginal cost to the spread between Pp and $\overline{Pm}$.

However, from [3-19] it can be concluded that given a common $\overline{Pm}$ and Pp, constrained refiners will probably have different

marginal costs in equilibrium because their values of $\partial Zm/\partial Vp$ will differ. The value of $\partial Zm/\partial Vp$ depends, in part, on the particular refiner's base period conditions and production possibilities. Furthermore, since $\partial Zm/\partial Vp$ is greater than zero, all constrained integrated retailers will have greater marginal costs than any unconstrained retailers (whose equilibrium condition would be shown by [3-18]).[1]

Anticompetitive Effects

The preceding result implies that the regulations can have a serious adverse effect on unconstrained independent retailers who compete with constrained integrated refiners.[2] For simplicity, it is assumed that both integrated refiners and unintegrated marketers purchase and retail gasoline at the same prices (Pp and $\overline{P}m$). Thus, in the absence of controls, marginal retailing cost would be equal across retailers and imply a level of total retail sales. The result that for any given retail margin ($\overline{P}m$-Pp), constrained integrated refiners will choose a higher retail sales

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[1] The fact that for constrained refiners $\partial Am/\partial Vm$ is greater than $\overline{P}m$-Pp also implies that the retailer is pricing his retailing services below their marginal cost. As a result it might seem that he is allocating an inefficiently high level of resource toward providing services. The implication that service will be more elaborate than it should be is, however, incorrect. In this model, volume is the only argument in the retailer's short-run cost function and thus, no inference can be drawn about the service quality.

[2] It is believed that the regulations have frequently been nonbinding at the retail level while they were binding on refiners.

volume in the short run than in the absence of controls therefore implies that for any given level of total retail sales, the sales of unintegrated marketers will be lower under the controls than in the absence of controls. This in turn implies that marginal marketing cost will be lower for these firms and therefore that the marketing margin will be lower than in the absence of controls. Thus, for any given level of total retail sales, the equilibrium marketing margin will be lower under the controls than in the absence of the controls.

The controls have this effect because they essentially induce constrained integrated refiners to cross-subsidize between their refining and marketing operations by reducing the shadow price of gasoline for the marketing operations of such refiners below its purchase price.[1]

This result seems to indicate that firms are aided by being constrained by the regulations, but that is not correct. An integrated refiner-marketer in the situation described would make greater profits if the regulations were removed; and absent the regulations, he would not operate so as to drive out efficient competitors. However, given that a refiner is constrained by the

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[1] It can be shown that the shadow price of gasoline to a constrained refiner-marketer is less than the price of purchased gasoline if in equilibrium $Pp - Pp^{\circ} - Xr + Xr^{\circ} > 0$. A sufficient, but not necessary, condition for this relationship to hold in equilbrium is that the marketing operations of the constrained refiner would not be constrained by the regulations if the operations were not affiliated with the refiner.

regulations, he is better off integrated into marketing; and he can realize that advantage only by marketing in a way that does damage efficient competitors.[1] It is essential to recognize that the source of this distortion is the way in which the regulations handle vertical integration. The regulations treat operations with common ownership jointly. This linking of marketing operations which would themselves be unconstrained with refiner operations which would by themselves be constrained serves to relax the constraints imposed by the regulations on the refiner.

SHORT-RUN REFINERY OUTPUT

In this model, it cannot be concluded (as it was in the model of chapter II) that the regulations invariably induce higher short-run refinery output (Vr). If some refiners are constrained, refinery volume, even in the short run (with K fixed), may be lower than it would be in the absence of regulation. This implies that market prices for petroleum products may be higher, even in the short run, due to the effects of the controls. The refiner's short-run refinery output can be examined as follows.

As noted previously, if $\lambda_1$ is set equal to zero, conditions [3-10]-[3-14] are profit-maximizing conditions for the refiner if he is unregulated, and Pm will equal $\overline{Pm}$. Therefore from [3-10] one can write

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1 Conversely, the nonintegrated, unconstrained marketers would be better off if they could integrate with constrained refiners.

[3-21] $(\partial L/\partial Vr)^* = G\bar{P}m + (1-G)Pu - (\partial Ar/\partial Vr)^* - G(\partial Am/\partial Vm)^* = 0$

as a profit-maximizing condition for the refiner in the absence of regulation. Since it was established that the refiner, when constrained by the regulations, will have $\lambda_1 > 0$ and $\lambda_2 > 0$ (and thus, Pm also equal to $\bar{P}m$), his corresponding equilibrium condition under regulation is

[3-22] $(\partial L/\partial Vr) = G\bar{P}m + (1-G)Pu - (\partial Ar/\partial Vr) - G(\partial Am/\partial Vm) + \lambda_1 (\partial Zm/\partial Vr) = 0.$

The $(\partial Am/\partial Vm)$ terms in [3-21] and [3-22] can be eliminated by noting that the unregulated equilibrium condition shown in [3-18] implies

[3-23] $(\partial Am/\partial Vm)^* = \bar{P}m - Pp$

and that [3-19], the corresponding equilibrium condition for the refiner when regulated, implies

[3-24] $(\partial Am/\partial Vm) = \bar{P}m - Pp + \lambda_1(\partial Zm/\partial Vp).$

Substituting [3-23] into [3-21] and [3-24] into [3-22], one can write

[3-25] $(\partial L/\partial Vr)^* = GPp + (1-G)Pu - (\partial Ar/\partial Vr)^* = 0$

an equilibrium condition for the refiner if he is unregulated,

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$$-26] \quad (\partial L/\partial Vr) = GPp + (1-G)Pu - (\partial Ar/\partial Vr) + \lambda_1\left(\frac{\partial Zm}{\partial Vr} - G\frac{\partial Zm}{\partial Vp}\right) = 0$$

he is regulated.[1] Comparing [3-25] and [3-26], assuming that e values of Pp and Pu are the same in both, it can be seen that finery output will be smaller (i.e., $\partial Ar/\partial Vr$ smaller) for the nstrained refiner if, in [3-26],

$$-27] \quad \frac{\partial Zm}{\partial Vr} - G\frac{\partial Zm}{\partial Vp} < 0.$$

A more meaningful expression for condition [3-27] can be tained as follows. It can be shown that when the refiner is nstrained ($\lambda_1>0$), condition [3-10] can be written[2]

$$-28] \quad \partial L/\partial Vr = G(Pm°-Xm°) - GXr° + (1-G)Pu - (1-G)(\partial Ar/\partial Vr) - \lambda_2(\partial Zm/\partial Vr) = 0.$$

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Implicit in [3-26] is the conclusion that, as in retailing, nstrained refiners will not have equal marginal refining costs market equilibrium. Therefore, the inefficient distribution of dustry production among refiners, noted in the first model, will cur with this model also.

Condition [3-28] is derived as follows. Note that with some nipulation (see [3-5])

$$n/\partial Vr = (G/Vm)[(\partial Ar/\partial Vr)-Xr°+(\partial Am/\partial Vm)-Xm°-Zm+Pm°];$$

at from [3-13], if $\lambda_1>0$ then Pm=Zm; and from [3-12] that $\lambda_1$ = -+Vp-$\lambda_2$. If these are substituted into [3-10] and the terms rranged, [3-28] can be obtained.

Note also from [3-16] that in the constrained equilibrium

[3-29] $G(\partial L/\partial Vp) = G(Pm°-Xm°) - GPp° - \lambda_2 G(\partial Zm/\partial Vp) = 0.$

Substituting into [3-28] the expression for $G(Pm°-Xm°)$ implicit in [3-29] yields

[3-30] $$\partial L/\partial Vr = G(Pp°-Xr°) + (1-G)Pu - (1-G)\frac{\partial Ar}{\partial Vr} - \lambda_2\left[\frac{\partial Zm}{\partial Vr} - G\frac{\partial Zm}{\partial Vp}\right] = 0.$$

Since $\lambda_2 > 0$ in the constrained equilibrium, [3-27] will hold if

[3-31] $G(Pp°-Xr°) + (1-G)Pu - (1-G)(\partial Ar/\partial Vr) < 0.$

In other words, if condition [3-31] holds in equilibrium for a constrained refiner, it implies that his output would be higher even in the short run if he were unregulated. Condition [3-31] will not necessarily describe any constrained refiner's equilibrium. However, since the first two terms are fixed while the last term (which is subtracted from them) is an increasing positive quantity, the condition is likely to hold for all refiners at some level of refinery output and could possibly describe the typical equilibrium.

A Higher Price Level?

As noted in conjunction with the simpler model, if market clearing prices prevail, the comparative price level between a regulated and an unregulated situation is a direct consequence of the level of supply. Therefore, only if the regulations induce an increased supply of petroleum products will prices be lower in the

short run due to the regulations. The possibility that condition [3-31] (and therefore [3-27]) could hold for the representative constrained refiner indicates that, even in the short run (capital held constant), the supply of petroleum products might be higher and prices lower without the regulations.

Holding Pp constant in the comparison of [3-25] and [3-26] that led to condition [3-27] does not undermine this conclusion. Note that if Pp is smaller in [3-25] than in [3-26], it could imply a larger output by the constrained refiner (a larger $\partial Ar/\partial Vr$ in [3-26] than in [3-25]) even though condition [3-27] was met. However, a smaller Pp in [3-25] would imply that aggregate refinery output was larger in the unregulated situation.

The Effect of Partial Decontrol

The reason the short-run output result in this model is different from that in the preceding model is that with partial decontrol, the refiner is no longer able to pass through all of his short-run marginal refining costs by boosting the ceiling price of his controlled products. Only a fraction of the cost of increasing Vr can be passed through. That fraction is equal to G, the fraction of gasoline in the refiner's output.[1]

The effect of partial decontrol can be seen by examining the profitability to the constrained refiner of increasing refinery runs when his ceiling price is below the market clearing level. This allows abstraction from the effect of purchased product.

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1 See the discussion of the "tilt" regulations in chapter IV.

The partial derivative $\partial L/\partial Vr$ can be interpreted as the marginal profitability of expanding output in the short run (holding K and G constant). If $\lambda 2$ is set equal to zero, $\partial L/\partial Vr$ is the marginal profitability when the ceiling price is below the market clearing level. From [3-28] one can write this marginal profitability for the constrained refiner as

[3-32] $G(Pm^{\circ}-Xr^{\circ}-Xm^{\circ}) + (1-G)Pu - (1-G)(\partial A/\partial Vr)$.

The term corresponding to [3-32] in the previous model (implicit in [2-14]) was M, the base period margin. It was assumed positive and invariant with output. The value of [3-32], however, is not necessarily positive at all levels of refinery output. In this model, the base period refinery margin is $Pm^{\circ}-Xr^{\circ}-Xm^{\circ}$. It is still assumed positive, but now the regulations provide for it only on the fraction of output that is controlled--the gasoline fraction G.

As noted above, with only a fraction of the output regulated, only a fraction of the cost of increasing Vr can be passed through by increasing the price of the controlled product. The remainder of the cost increase (in this model equal to $(1-G)(\partial Ar/\partial Vr)$) must be covered by the marginal revenue from the uncontrolled product ($(1-G)Pu$). Otherwise, the cost increase reduces the allowed profit margin ($G(Pm^{\circ}-Xr^{\circ}-Xm^{\circ})$) on the additional controlled output. As marginal cost increases relative to

the market value of the uncontrolled product,[1] the profit margin on additional output can drop to zero and then become negative, even if market conditions allow the full ceiling price increase to be collected.

It is the inability of the refiner to pass through all his short-run refinery cost increases that may cause him to refine less under the controls than he would in the absence of controls.

LONG-RUN ANALYSIS: INPUT MIX

The constrained refiner's ratio of capital to variable inputs will, as in the first model, be lower than the cost-minimizing ratio. This is true for both his refining and marketing operations. This occurs, as in the model of chapter II, because the regulations do not allow increases in the equity cost of capital to be passed through.

This result can be shown using conditions [3-7] and [3-8]. For the constrained refiner $\lambda_1 > 0$ and from [3-12]

[3-33] $\lambda_1 = GVr + Vp - \lambda_2$.

Therefore, conditions [3-7] and [3-8] can be rewritten

$$[3\text{-}34] \quad -\left(1-G+\frac{G\lambda_2}{GVr+Vp}\right)\frac{\partial Ar}{\partial Kr} = \left(1-G+\frac{G\lambda_2}{GVr+Vp}\right)\frac{\partial Nr}{\partial Kr}+\frac{\partial Rr}{\partial Kr}$$

---

1 Uncontrolled product has a much lower per-unit value than the products such as gasoline that remain controlled.

and

$$[3\text{-}35] \quad -\left(\frac{\lambda_2}{GVr+Vp}\right)\frac{\partial Am}{\partial Km} = \left(\frac{\lambda_2}{GVr+Vp}\right)\frac{\partial Nm}{\partial Km} + \frac{\partial Rm}{\partial Km}.$$

Equations [3-34] and [3-35] describe the refiner's location along any given isoquant in Kr, Qr space and Km, Qm space respectively. (For refining, an isoquant would designate a G, Vr pair, for marketing a Vm.) Since from inspection of [3-33] it can be determined that if $\lambda_1 > 0$, then

$$[3\text{-}36] \quad 0 < \frac{G\lambda_2}{GVr+Vp} < G,$$

the bracketed terms in [3-34] and [3-35] are positive fractions. That implies that

$$[3\text{-}37] \quad -(\partial Ai/\partial Ki) > (\partial Ni/\partial Ki)+(\partial Ri/\partial Ki),$$

which, in turn, implies that Ki/Qi will be lower than the cost-minimizing ratio in equilibrium.

This means that whether the refiner produces a lower or higher output in the long run due to the regulations, he can be expected to produce and market it at an unnecessarily high cost.

LONG-RUN REFINERY OUTPUT LEVEL

Comparison of the long-run output with and without the regulations appears to require the full specification of the model as well as the expected prices with and without regulation. The authors have found no general comparative equilibrium solution.

Conceptually, the solution process would be similar to that illustrated by figure 2-2. It would, however, be much more complicated. A level of capital and an output level would have to be found for both refining and marketing, and the choices would interact. From [3-34] it is known that the constrained firm's refinery input mix would again be located to the right of the $E^P$ curve, but the simple rule of locating at the point on each isoquant at which the ceiling price was equal to the market clearing price would not always be valid. The full specifications of [3-34] would have to be known. Also, a product mix (G) dimension would have to be added to figure 2-2.

Such a procedure could be followed as before, however, to define the constrained refiner's costs as a function of output (given expected prices) when capital is allowed to vary. These "long-run cost" functions--$\tilde{Ar}(Vr,G)$, $\tilde{Nr}(Vr,G)$ $\tilde{Rr}(Vr,G)$, $\tilde{Am}(Vm)$, $\tilde{Nm}(Vm)$, $\tilde{Rm}(Vm)$, all based on the expected levels of Pm, Pu, and Pp--could be used to write a long-run constrained profit function,

$$[3\text{-}38]\quad \tilde{\Pi} = Zm(GVr+Vp) + Pu(1-G)Vr - \tilde{Ar} - \tilde{Nr} - \tilde{Rr} - \tilde{Am} - \tilde{Nm} - \tilde{Rm} - PpVp,$$

which, when Zm is expanded incorporating the relevant "cost" expressions, can be reduced to

$$[3\text{-}39]\quad \tilde{\Pi} = VmPm^{\circ} - GVrXr^{\circ} - VpPp^{\circ} - VmXm^{\circ} + Pu(1-G)Vr - (1-G)(\tilde{Ar}+\tilde{Nr}) - \tilde{Rr} - \tilde{Rm}.$$

As in the first model, the cost functions are defined to conform to the market price constraint. The profit-maximizing conditions for the constrained refiner with respect to Vr and Vp are

$$[3\text{-}40]\quad \frac{\partial \tilde{\Pi}}{\partial Vr} = G(Pm°-Xr°-Xm°) + Pu(1-G) - (1-G)\left(\frac{\partial \tilde{Ar}}{\partial Vr} + \frac{\partial \tilde{Nr}}{\partial Vr}\right) - \frac{\partial \tilde{Rr}}{\partial Vr} - G\frac{\partial \tilde{Rm}}{\partial Vr} = 0$$

$$[3\text{-}41]\quad \frac{\partial \tilde{\Pi}}{\partial Vp} = Pm°-Pp°-Xm° - \frac{\partial \tilde{Rm}}{\partial Vm} = 0.$$

As with the preceding model, the suggestion here is that the refiner will essentially equate his base period margin to his marginal nonallowable costs; but again, given the peculiar "cost" functions, this result suggests no general relationship to the choice of an unregulated refiner.

OUTPUT MIX

A refiner can vary his output mix (implicit in the level of the gasoline fraction (G)). This capability was ignored in the preceding analysis so as to isolate other effects of the controls.

The constrained refiner's product mix choice is likely to be inefficient. A necessary condition for the efficient choice of G is that the price difference between the two products equal the marginal cost of transforming a unit of uncontrolled product into a unit of controlled product. In the short run, in terms of this model, that is

$$[3\text{-}42] \quad \bar{P}m - Pu = \frac{1}{Vr}\left[\frac{\partial Ar}{\partial G} + \frac{\partial Am}{\partial G}\right]$$

and in the long run

$$[3\text{-}43] \quad \bar{P}m - Pu = \frac{1}{Vr}\left[\frac{\partial(Ar+Nr+Rr)}{\partial G} + \frac{\partial(Am+Nm+Rm)}{\partial G}\right].$$

The constrained refiner's profit-maximizing condition in the short run is (from [3-9], [3-13] and [3-14] if $\lambda 1>0$ and $\lambda 2>0$)

$$[3\text{-}44] \quad \bar{P}m - Pu = \frac{1}{Vr}\left(\frac{\partial Ar}{\partial G} + \frac{\partial Am}{\partial G}\right) - \frac{\lambda_1}{Vr}\left(\frac{\partial Zm}{\partial G}\right)$$

and in the long run (from [3-39])

$$[3\text{-}45] \quad Pm^{\circ} - Xr^{\circ} - Xm^{\circ} - Pu = \frac{1}{Vr}\left(\frac{\partial \tilde{Rr}}{\partial G} + \frac{\partial \tilde{Rm}}{\partial G}\right) + \frac{1-G}{Vr}\left(\frac{\partial \tilde{Ar}}{\partial G} + \frac{\partial \tilde{Nr}}{\partial G}\right) + \frac{1}{Vr}(\tilde{Ar}+\tilde{Nr}).$$

The right-hand side of [3-44] misstates the marginal cost of increasing G (implying that the refiner will have an inefficient G given his costs) unless $\partial Zm/\partial G$ is equal to zero. It can be shown that (see [3-5])

$$[3\text{-}46] \quad \frac{\partial Zm}{\partial G} = \frac{1}{Vm}\left[\frac{VrVp}{Vm}[(Xr-Xr^{\circ})-(Pp-Pp^{\circ})] + G\left(\frac{\partial Ar}{\partial G}\right) + Vr\left(\frac{\partial Am}{\partial Vm} - \frac{Am+Nm}{Vm}\right)\right],$$

an expression unlikely to equal zero.

It is expected that $\partial Zm/\partial G$ would usually be greater than zero. Sufficient (but not all necessary) conditions for $\partial Zm/\partial G>0$ are that average refining costs have risen more than average purchased gasoline prices since the base period, the marginal cost of increasing G is positive, and average short-run retailing costs are rising. While the first condition is very difficult to assess, the second condition certainly holds, since gasoline is one of the most costly refined products, and the third condition would be unexceptional.

If $\partial Zm/\partial G$ is greater than zero, it implies that the right-hand side of [3-44] understates the marginal cost of increasing G.[1] This means that given his marginal conversion cost, the constrained refiner will achieve an inefficiently high G in the short run. He will increase the output of gasoline when its marginal cost, including both increased resource use and the value of the foregone uncontrolled products, is greater than the marginal value of gasoline to consumers. All other things being equal, this would result in a comparatively greater G with regulation; however, the constrained refiner is likely to produce at a different K and V. As a result, he may have a higher marginal product transformation cost in the constrained equilibrium; and the comparative level of G cannot be generally specified.

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[1] The motivation for this result is that the refiner can pass through a greater fraction of this refining costs if he has a higher G.

In the long run, a comparison of [3-43] and [3-45] does not allow any inference about the difference in G that will result from regulation.

It should also be noted that the marginal cost of increasing total volume is not independent of G. Thus, if G had been allowed to vary during the analysis of comparative output levels, the results would have been altered somewhat. In general, it would be expected that marginal volume increases would be more costly with a higher G. Therefore, since it is expected that the constrained refiner will generally tend to choose a higher G, the conclusion that short-run output may be lower for the refiner due to regulation (arrived at by comparing $\partial Ar/\partial Vr$ in [3-25] and [3-26]) is reinforced. It also means, however, that there is some possibility that even though total refinery output (Vr) would be lower if condition [3-27] held, gasoline output (GVr) could be higher. It follows, then, that while the weighted average prices of petroleum products would also be higher if [3-27] described the representative refiner, the price of gasoline might be lower. In general, it would be anticipated that due to the regulations, the prices of uncontrolled products such as heating oil would be higher relative to the price of gasoline.

# CHAPTER IV

## TILT REGULATIONS AND MARKET POWER

In this chapter, the effects of two unrelated modifications of the preceding models are examined. First, the gasoline tilt regulations, which allow a greater than proportional attribution of refining costs to gasoline, are incorporated into the model of the partially decontrolled firm. It is shown that the tilt modifications do not qualitatively affect any of the previous results.

Second, the assumption that the regulated firms are price takers is relaxed to examine the predictions of the preceding models under the assumption that the firms have market power. The primary change due to this alteration of the models is that the constrained firm with market power will not necessarily have a price lower than marginal cost in equilibrium. The ramifications of this change are discussed in the second section of the chapter.

### TILT REGULATIONS

The preceding analysis indicates that if the cost increases that must be allocated to uncontrolled products are large relative to the market value of the uncontrolled products, refinery output may be reduced. The "gasoline tilt" provisions of the price regulations were instituted by DOE in March 1979, to allow

allocation of refining costs to gasoline on a greater than pro rata volumetric basis.[1]

Under the tilt regulations, a refiner is allowed to allocate to gasoline as much as 110 percent of the crude oil costs attributable to gasoline on a pro rata volumetric basis. The proportion of allowable nonproduct refining cost (e.g., depreciation and interest capital costs) that may be allocated to gasoline with the tilt modification is

[4-1] $1-(1-G)^2 = 2G-G^2$,

where, as before, G is the volumetric fraction of gasoline in the refinery output of the firm.

Tilt can be incorporated into the preceding model by rewriting the ceiling price formula:

$$[4\text{-}2] \quad Zt = Pm^\circ + (1.1)\left(\frac{GVr}{Vm}\right)\left(\frac{Ar}{Vr} - \frac{Ar^\circ}{Vr^\circ}\right) + (2G-G^2)\left(\frac{Vr}{Vm}\right)\left(\frac{Nr}{Vr} - \frac{Nr^\circ}{Vr^\circ}\right)$$

$$+ \left(\frac{Vp}{Vm}\right)(Pp-Pp^\circ) + Xm - Xm^\circ$$

or

$$[4\text{-}3] \quad Zt = Zm + \frac{GVr}{Vm}\left[(0.1)\left(\frac{Ar}{Vr} - \frac{Ar^\circ}{Vr^\circ}\right) + (1-G)\left(\frac{Nr}{Vr} - \frac{Nr^\circ}{Vr^\circ}\right)\right],$$

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[1] The tilt modifications were justified by DOE as being necessary "to improve the investment climate for expansion or modification of refineries and, thus, to prevent shortages of gasoline, particularly unleaded gasoline," 44 F.R. 15600 (March 14, 1979).

with Zm being the ceiling price prior to the tilt modification, defined in [3-4].

The refiner's profit function would be unaltered from [3-1], but the new constraint would cause the relevant Langrangian function to be written with Zt in place of Zm:

$$[4\text{-}4] \quad L = \Pi - \lambda_1(Zt-Pm) + \lambda_2(\bar{P}m-Pm).$$

Assuming that Vr, Kr, Km, G, Pm, and Vp are all greater than zero, the first order conditions with tilt (paralleling [3-7]-[3-14]) are

$$[4\text{-}5] \quad \frac{\partial L}{\partial Kr} = -\frac{\partial Ar}{\partial Kr} - \frac{\partial Nr}{\partial Kr} - \frac{\partial Rr}{\partial Kr} + \frac{G\lambda 1}{GVr+VP}\left[(1.1)\frac{\partial Ar}{\partial Vr} + (2-G)\frac{\partial Nr}{\partial Kr}\right] = 0$$

$$[4\text{-}6] \quad \frac{\partial L}{\partial Km} = -\frac{\partial Am}{\partial Km} - \frac{\partial Nm}{\partial Km} - \frac{\partial Rm}{\partial Km} + \frac{\lambda 1}{GVr+Vp}\left(\frac{\partial Am}{\partial Km} + \frac{\partial Nm}{\partial Km}\right) = 0$$

$$[4\text{-}7] \quad \frac{\partial L}{\partial G} = Vr(Pm-Pu) - \frac{\partial Ar}{\partial G} - \frac{\partial Am}{\partial G} + \lambda 1\left(\frac{\partial Zt}{\partial G}\right) = 0$$

$$[4\text{-}8] \quad \frac{\partial L}{\partial Vr} = GPm + (1-G)Pu - \frac{\partial Ar}{\partial Vr} - G\frac{\partial Am}{\partial Vm} + \lambda 1\left(\frac{\partial Zt}{\partial Vr}\right) = 0$$

$$[4\text{-}9] \quad \frac{\partial L}{\partial Vp} = Pm - Pp - \frac{\partial Am}{\partial Vm} + \lambda 1\left(\frac{\partial Zt}{\partial Vp}\right) = 0$$

$$[4\text{-}10] \quad \frac{\partial L}{\partial Pm} = GVr + Vp - \lambda 1 - \lambda 2 = 0$$

[4-11] $\lambda_1 \left(\frac{\partial L}{\partial \lambda_1}\right) = \lambda_1(Zt - Pm) = 0$

[4-12] $\lambda_2 \left(\frac{\partial L}{\partial \lambda_2}\right) = \lambda_2(\overline{Pm} - Pm) = 0.$

The discussion of this model will closely parallel that of th preceding model and because of marked similarities will be sub stantially abbreviated.

Equilibria and Market Clearance

As with the preceding model, the refiner is unconstrained i $\lambda_1 = 0$ in the profit-maximizing equilibrium solution of the model With tilt, the condition for the refiner to be unconstrained in th short run (corresponding to [3-15] in the preceding model) is that at his free market output,

[4-13] $Vm[(Pm°-Pp°-Xm°)-(\overline{Pm}-Pp-Xm)] + GVr[(Pp°-Xr°) - (Pp-Xr)]$

$$+ GVr[(0.1)(\frac{Ar}{Vr} - \frac{Ar°}{Vr°}) + (1-G)(\frac{Nr}{Vr} - \frac{Nr°}{Vr°})] > 0.$$

Condition [4-13] holds at some price and output combinations a which [3-15] does not hold. This implies that a refiner is mor likely to be unconstrained with the tilt modification than with out. However, condition [4-13] will not necessarily hold for an refiner, and the implications of the constrained equilibria ar still important.

The constrained equilibria in which the refiner charges less than the market clearing price ($\lambda_2=0$) can be ruled out just as in the preceding model. If $\lambda_1>0$, condition [4-9] can be shown equivalent to[1]

[4-14] $\partial L/\partial Vp = Pm^\circ - Pp^\circ - Xm^\circ - \lambda_2(\partial Zt/\partial Vp) = 0,$

which is very similar to condition [3-16] and has the same interpretation. If $Pm^\circ-Pp^\circ-Xm^\circ>0$ (the likely condition for most refiners), $\lambda_2=0$ (which implies that the the ceiling price may be less than the market clearing price) is not a viable solution to the model. Tilt, therefore, does not alter the conclusion that market clearance is the normally expected equilibrium for a constrained refiner.

Retailing

The equilibrium condition in this model analogous to [3-19] in the preceding model is

[4-15] $\partial L/\partial Vp = \bar{P}m - Pp - (\partial Am/\partial Vm) + \lambda_1(\partial Zt/\partial Vp) = 0.$

Since [3-18] still shows the equivalent equilibrium condition for the refiner in the absence of regulation, showing $\partial Zt/\partial Vp>0$ is sufficient to establish that given a $\bar{P}m$, Pp pair, the refiner's retail sales volume (implied by the level of $\partial Am/\partial Vm$) will be higher with the regulation than without. It is implicit in [4-14]

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1 The derivation of [4-14] closely parallels that of [3-16]. Note that $\partial Zt/\partial Vp=(1/Vm)[Pp-Pp^\circ+(\partial Am/\partial Vm)-Xm^\circ+Pm^\circ-Zt]$.

that $\partial Zt/\partial Vp>0$ will generally be the case. Therefore, all the conclusions regarding marketing that were drawn in the context of the preceding model are qualitatively unaltered by the tilt modifications.

Short-Run Refinery Output

The tilt modifications also do not change the conclusion that the regulations may result in lower refinery output and therefore higher prices than would prevail in the absence of controls.

Paralleling the steps used to derive [3-26] in the analysis of the preceding model, the analogous equilibrium condition in the model with tilt can be shown to be

$$[4\text{-}16] \quad (\partial L/\partial Vr) = GPp + (1-G)Pu - (\partial Ar/\partial Vr) + \lambda_1\left[\frac{\partial Zt}{\partial Vr} - G\frac{\partial Zt}{\partial Vp}\right] = 0.$$

Equation [3-25] still shows the equilibrium condition for the refiner in the absence of regulation. It follows, therefore, that given Pp and Pu, the refinery output will be smaller for the constrained refiner subject to tilt than for the same refiner in the absence of regulation, if in [4-16]

$$[4\text{-}17] \quad \frac{\partial Zt}{\partial Vr} - G\frac{\partial Zt}{\partial Vp} < 0.$$

A condition equivalent to [4-17] can be identified by first noting that a profit-maximizing equilibrium condition for the constrained refiner is[1]

$$[4\text{-}18]\quad \partial L/\partial Vr = G(Pp^\circ - Xr^\circ) + (1-G)Pu - (1-G)\frac{\partial Ar}{\partial Vr} + G(0.1)\frac{\partial Ar}{\partial Vr}$$

$$-G(0.1)\frac{Ar^\circ}{Vr^\circ} - (G-G^2)\frac{Nr^\circ}{Vr^\circ} - \lambda_2\left[\frac{\partial Zt}{\partial Vr} - G\frac{\partial Zt}{\partial Vp}\right] = 0.$$

Since $\lambda_2 > 0$ in the constrained equilibrium, [4-18] implies that [4-17] will hold if

$$[4\text{-}19]\quad G(Pp^\circ - Xr^\circ) + (1-G)Pu - [1-G(1.1)]\frac{\partial Ar}{\partial Vr} - (0.1)G\frac{Ar^\circ}{Vr^\circ}$$

$$- (G-G^2)\frac{Nr^\circ}{Vr^\circ} < 0.$$

Condition [4-19] is analogous to [3-31] in the previous model. As in [3-31], the fact that $\partial Ar/\partial Vr$ is likely to increase rapidly with $Vr$ above some level of output indicates that a reduced refinery volume due to the regulations cannot be ruled out in the absence of an empirical analysis.

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1 The derivation of condition [4-18] parallels that of condition [3-30]. Note that

$$\frac{\partial Zt}{\partial Vr} = \frac{G}{Vm}\left[(1.1)\frac{\partial Ar}{\partial Vr} - Xr^\circ + \frac{\partial Am}{\partial Vm} - Xm^\circ - Zt + Pm^\circ - (0.1)\frac{Ar^\circ}{Vr^\circ}\right.$$

$$\left. - (1-G)\frac{Nr^\circ}{Vr^\circ}\right].$$

It is not even clear that the tilt modification will cause a constrained regulated firm to refine more than it would have in the absence of tilt. Prior to the introduction of tilt, a constrained refiner would have selected a Vp and Vr such that $Zm=\overline{P}m$. Since for any given Vp, Vr pair, $Zt>Zm$, the refiner would find himself after the tilt modification with $Zt>\overline{P}m$ if he maintained the same Vp and Vr that he had selected prior to the tilt modification. If the refiner is still constrained at his post-tilt equilibrium, it was established above that he will maximize profits by setting $Zt=\overline{P}m$. He will, therefore, have to adjust Vp and/or Vr from their pre-tilt levels to reduce Zt. It is possible that this downward adjustment of Zt would involve an increase in Vr over the level selected in the absence of tilt, but a reduction is also possible.

It would appear that an increase in refinery output in response to tilt would be most likely for a constrained refiner who in the absence of tilt would have refined less than he would have in the absence of regulation. For such a refiner, $\partial Zm/\partial Vr$ would have been negative, leading to the presumption that the decrease in the ceiling price necessary to reestablish equality with $\overline{P}m$ might involve an increase in Vr. This presumption cannot be relied upon, however, because $\partial Zt/\partial Vr$ at the pre-tilt level of Vr and Vp may be larger than zero, even though $\partial Zm/\partial Vr$ was smaller than zero.

Both

$$[4\text{-}20]\quad \partial Zt/\partial Vr - \partial Zm/\partial Vr = \frac{G}{Vm}\left[(0.1)\frac{\partial Ar}{\partial Vr} - (0.1)\frac{Ar^{\circ}}{Vr^{\circ}} - (1-G)\frac{Nr^{\circ}}{Vr^{\circ}}\right.$$

$$\left. - \frac{GVr}{Vm}\left[(0.1)\left(\frac{Ar}{Vr} - \frac{Ar^{\circ}}{Vr^{\circ}}\right) - (1-G)\left(\frac{Nr}{Vr} - \frac{Nr^{\circ}}{Vr^{\circ}}\right)\right]\right]$$

and

$$[4\text{-}21]\quad [\partial Zt/\partial Vr - G(\partial Zt/\partial Vp)] - [\partial Zm/\partial Vr - G(\partial Zm/\partial Vp)] =$$

$$\frac{G}{Vm}\left[(0.1)\frac{\partial Ar}{\partial Vr} - (0.1)\frac{Ar^{\circ}}{Vr^{\circ}} - (1-G)\frac{Nr^{\circ}}{Vr^{\circ}}\right]$$

may be greater than, equal to, or less than zero.

Long-Run Refinery Output

The possibility that the tilt modification might induce the constrained refiner to increase his output appears to be greater in the long run.

With the tilt modification, the constrained refiner's long-run profit function (analogous to [3-38] in the preceding model) would be

$$[4\text{-}22]\quad \tilde{\Pi}t = Zt(GVr+Vp) + Pu(1-G) - \tilde{Ar} - \tilde{Nr} - \tilde{Rr} - \tilde{Am} - \tilde{Nm} - \tilde{Rm} - PpVp.$$

If the long-run "cost functions" ($\tilde{Ai}$, $\tilde{Ni}$, $\tilde{Ri}$) were unchanged by tilt, we could write [4-22] as

$$[4\text{-}23]\quad \tilde{\Pi}t = \tilde{\Pi} + GVr\left[(0.1)\left(\frac{\tilde{Ar}}{Vr} - \frac{Ar^{\circ}}{Vr^{\circ}}\right) + (1-G)\left(\frac{\tilde{Nr}}{Vr} - \frac{Nr^{\circ}}{Vr^{\circ}}\right)\right],$$

where $\tilde{\Pi}$ is the long-run profit function in the absence of tilt defined in [3-38] and [3-39]. The refiner's profit-maximizing long-run refinery output would be determined by

$$[4\text{-}24] \quad \frac{\partial \tilde{\Pi}t}{\partial Vr} = \frac{\partial \tilde{\Pi}}{\partial Vr} + G[(0.1)(\frac{\partial \tilde{Ar}}{\partial Vr} - \frac{Ar^\circ}{Vr^\circ}) + (1\text{-}G)(\frac{\partial \tilde{Nr}}{\partial Vr} - \frac{Nr^\circ}{Vr^\circ})] = 0,$$

where $\partial\tilde{\Pi}/\partial Vr = 0$ is the equilibrium condition for the refiner in the absence of tilt shown in [3-40]; i.e.,

$$[3\text{-}40] \quad \frac{\partial \tilde{\Pi}}{\partial Vr} = G(Pm^\circ\text{-}Xr^\circ\text{-}Xm^\circ) + Pu(1\text{-}G) - (1\text{-}G)(\frac{\partial \tilde{Ar}}{\partial Vr} + \frac{\partial \tilde{Nr}}{\partial Vr}) - \frac{\partial \tilde{Rr}}{\partial Vr} - G\frac{\partial \tilde{Rr}}{\partial Vr} = 0.$$

Since the term added to $\partial\tilde{\Pi}/\partial Vr$ in [4-24] can be expected to be positive at relevant outputs, it might be presumed that tilt would result in increased refinery output relative to the output of the constrained refiner in the absence of tilt. This conclusion would rely, however, on the assumption that the "cost functions" were unaltered by tilt. In fact, tilt may cause the refiner to change his long-run input mix choice; and that in turn could cause equity cost ($\tilde{Rr}$) to be higher relative to crude oil ($\tilde{Ar}$) and other capital costs ($\tilde{Nr}$) at the margin for any given output. Such a change in the cost functions could possibly cause [4-24] to hold at a lower Vr than [3-40]. Using general functional forms, therefore, it does not appear possible to rule out the result that tilt could cause lower rather than higher output in the long run as well as the short run.

Input Mix

The change in refinery input mix (and thus long-run cost as a function of output) occasioned by tilt can be seen by examining condition [4-5]. Substituting for $\lambda_1$ from [4-10] and rearranging the terms allows [4-5] to be written

$$[4\text{-}25]\quad -\left[1-\frac{G(1.1)(Vm-\lambda 2)}{Vm}\right]\frac{\partial Ar}{\partial Vr}=\left[1-\frac{G(2-G)(Vm-\lambda 2)}{Vm}\right]\frac{\partial Nr}{\partial Vr}+\frac{\partial Rr}{\partial Vr}\,.$$

Comparing [4-25] with the equivalent condition absent the tilt modification, shown in [3-34], it can be determined that the optimal factor mix choice at any given output is likely to be altered by tilt. Therefore, it is unlikely that the long-run cost functions in [4-23] will be the same as those in [3-40]. It cannot be determined in general, however, what the qualitative effect on long-run marginal refining costs of the altered input mix will be.

Comparing [4-25] with [3-34] also leads to the conclusion that the qualitative effect of tilt on the efficiency of the capital/variable-input ratio selected at any given output is ambiguous. Tilt could cause a refiner to select a more efficient capital output ratio than if he were constrained in the absence of tilt, but tilt could also cause him to select a less efficient ratio.

Additional Inefficiency Due to Tilt

An unambiguous effect of tilt is a distortion of the refiner's mix of variable inputs. In the model above, this effect does

not appear because it has been assumed that there is only one variable refinery input--crude oil. There are actually many variable inputs to refining (labor, chemicals, etc.); and there are substitution possibilities between these inputs and crude oil. The non-crude-oil variable inputs are treated like allowable capital costs under the tilt modification of the ceiling price formula. Although this feature will not be formally modeled, its effect is clear.[1] Just as the refiner tended to favor crude oil over capital when a larger portion of crude oil than of capital cost increases could be passed through, the refiner under tilt will tend to favor, in his choice of variable inputs, those variable inputs for which a larger proportion of cost increases can be passed through. For most refiners (given their choice of G) the tilt for crude oil costs will be smaller than the tilt for other costs. This will mean that for any given output, the constrained refiner's profit-maximizing ratio of variable non-crude-oil inputs to crude oil will be higher than the ratio that would minimize cost.

MARKET POWER

The analysis in preceding chapters assumed that the firms subject to the regulations behave as price-takers. In this section the alternative that the firm has market power is examined.

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[1] This effect can be seen in [4-25]. If the input whose quantity is designated Kr and whose cost is designated by N and R had been a variable input, such as chemical catalyst, rather than capital, the nonallowable portion of the cost, R, would equal zero. With $\partial R/\partial Vr$ set equal to zero, therefore, condition [4-25] would show the necessary profit-maximizing condition for the crude oil/catalyst mix at any given output.

Most of the previously derived results remain the same with this change, but some are altered.

If the models are modified to give the firm monopoly power, the following results concerning binding regulation are unchanged: (1) There will generally be market clearance.[1] (2) The firm will employ an inefficient input mix. (3) The firm may purchase gasoline when it could refine gasoline itself at a lower marginal cost. (4) If the firm is an integrated refiner-marketer, it will sell more at retail than it would in the absence of controls. (5) The amount of product supplied by the firm may be higher or lower than it would be absent controls; therefore, prices may be higher or lower than they would be in the absence of controls.

The primary result that is altered by assuming monopolistic rather than price-taking behavior is that with market power, binding regulations will not necessarily result in price lower than marginal cost. Since a firm with monopoly power maximizes profits by selecting a price higher than marginal cost, the fact that the regulations constrain the refiner's price closer to average cost than he would freely choose may only cause his price to move toward or to marginal cost rather than below marginal cost.

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1 Even in the traditional price control model, the price ceiling may be binding on a monopolist without inducing a shortage. This would be true, however, only as long as marginal cost is lower than the ceiling price at the volume demanded at the ceiling price. With DOE controls, a market clearing equilibrium is possible even with a ceiling price below marginal cost at the market clearing output.

Consequently, the regulations may induce a more efficient allocation of resources toward the activity of supplying petroleum products than would occur in the absence of regulations.[1]

In the face of this relatively sanguine result, it should be repeated that the regulations can still be shown to induce inefficiencies that raise the cost to the firm of supplying any given level of output and that the net result may be a higher price than in the absence of regulation.

The other results affected by assuming market power on the part of the constrained firm are those concerning the distribution of output among firms in the industry. For convenience in the discussion below, the firm with market power is referred to as a "monopolist"; and, of course, if he were actually a monopolist, any market share questions would be moot. On the other hand, the analytical results are applicable to other firms facing a downward sloping demand curve; and if the constrained firm is part of an oligopolistic or monopolistically competitive industry, the question of market share is relevant. In both these latter cases, however, the free-market distribution of output among firms may be inefficient. Therefore, the fact that the regulated equilibrium is characterized by firms with unequal marginal costs does not necessarily imply (as it did in the case of price-takers) that

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[1] Even if price is pushed below marginal cost, the result may be more efficient than that chosen by the monopolist in the absence of regulations, since the free market choice of the monopolist would be an inefficient price greater than marginal cost.

market shares are less efficient than they would be absent the regulations.

The adverse effect of the regulations on competition discussed in chapter III is also less certain if the integrated refiner-marketer has market power. The regulations will induce the integrated firm with market power to sell more at retail than it would absent controls and to accept a lower retail margin than in the absence of controls. This, in turn, may drive out unintegrated marketers. However, the regulations will not necessarily force the integrated marketer's retail margin below his marginal nonproduct marketing cost. Consequently, if the displaced firms are competitors, it does not necessarily follow that they are as efficient as the integrated firm. In addition, if the integrated firm and the displaced marketers are monopolistic competitors, it does not necessarily follow (because of the questionable efficiency of monopolistically competitive free-market equilibria) that social welfare is reduced, even if the displaced marketers are as efficient as the integrated firm.

The proofs of the monopoly results parallel those of the price-taker very closely. The discussion below will be abbreviated, therefore, by relying heavily on the preceding chapters.

The Basic Model

The effect of market power is incorporated in the preceding models by making the market clearing price a function of the output of the regulated firm. When this modification is made to

the single product model of chapter II, the only alteration of the first order conditions is the addition of the term $\lambda_2(\partial\overline{P}/\partial V)$ to $\partial L/\partial V$ shown in [2-9]. This yields

$$[4\text{-}26] \quad \frac{\partial L}{\partial V} = P - \frac{\partial A}{\partial V} + \frac{\lambda_1}{V}\left[\frac{\partial A}{\partial V} - \frac{A+N}{V}\right] + \lambda_2\left(\frac{\partial \overline{P}}{\partial V}\right) = 0.$$

The other change in the analysis is an alteration of the condition under which the firm is unconstrained, from that shown in [2-13] to

$$[4\text{-}27] \quad \overline{P} = \frac{\partial A}{\partial V} - V\frac{\partial \overline{P}}{\partial V} \leq M + \frac{A+N}{V}.$$

This change follows from the fact that the firm with market power maximizes profits by setting marginal revenue, rather than price, equal to marginal cost.

The proof in chapter II that a constrained refiner will generally have a ceiling price equal to the market clearing price is unaltered for the monopolist, since $\lambda_2$ is set equal to zero in that proof. The relevant first order conditions are therefore the same with or without market power.

The regulated short-run equilibrium with market power can be illustrated with figure 4-1. The marginal cost (MC) and ceiling price (CP) curves have the same interpretation as in previous diagrams. The firm no longer faces an exogenously determined market clearing price, however, but instead has a downward sloping demand curve (D) with an associated marginal revenue curve (MR).

In the absence of regulations, the monopolist refiner would maximize profits by producing output Vu, at which his marginal revenue equals his marginal cost; and he would charge the price (Pu) that would clear the market at that output. If the refiner's demand curve lay below the CP curve at output Vu, the refiner would be unconstrained. However, in the situation portrayed, the firm is allowed to charge a price of only Zu if it produces Vu; and the profit-maximizing calculus is altered by the regulations.

As noted above, the result that the constrained regulated refiner will find it profitable to expand output until his ceiling price equals the market clearing price is valid with the market-power model just as it was with the price-taker model. Thus in figure 4-1 the regulated equilibrium output can be identified as Vr, the output at which the demand curve intersects the ceiling price curve and the ceiling price equals the market clearing price.[1]

The equilibrium shown in figure 4-1 is characterized by a regulated price lower than marginal cost (Pr<MCr). Had the demand curve intersected (from above) the CP curve to the left of $V_1$, however, the regulated equilibrium price would exceed marginal

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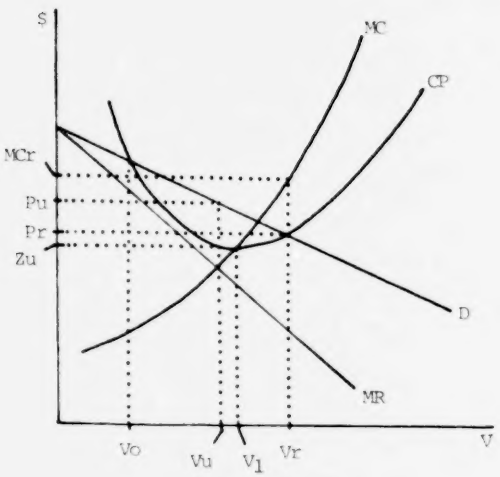
1 The marginal revenue allowed the firm by the regulations would be equal to the unregulated marginal revenue up to output Vo (at which the demand curve falls below the CP curve); it would exceed marginal cost by M between Vo and Vr; and it would drop back to the unregulated marginal revenue curve at Vr and follow that curve for outputs above Vr.

FIGURE 4-1



cost. In the unlikely event that the demand curve intersected CP precisely at V1, price would equal marginal cost as it would in a competitive free market.

In chapter II, the first order condition in [2-9] was used to show mathematically both that short-run output under regulation would be higher than in the absence of regulation and that the regulated equilibrium price would be below marginal cost.[1] Only the first of these results will necessarily hold if the representative firm has market power. If the representative firm has market power, the first order condition equivalent to [2-9] is that shown in [4-26]. Note that for an unconstrained refiner with market power

$$[4\text{-}28] \quad P + V\frac{\partial \overline{P}}{\partial V} = \frac{\partial A}{\partial V}$$

in the short run. Condition [4-26] implies, therefore, that if

$$[4\text{-}29] \quad P + \lambda_2\frac{\partial \overline{P}}{\partial V} + \frac{\lambda_1}{V}\left(\frac{\partial A}{\partial V} - \frac{A+N}{V}\right) > P + V\frac{\partial \overline{P}}{\partial V} ,$$

then $\partial A/\partial V$ (and thus short-run output) is greater under regulation than in the absence of regulation. Condition [4-29] can be shown (by substituting $\lambda_2 = V-\lambda_1$ from [2-10] into [4-29]) to hold if

$$[4\text{-}30] \quad \left(\frac{\partial A}{\partial V} - \frac{A+N}{V}\right) - V\frac{\partial \overline{P}}{\partial V} > 0 ;$$

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1 See footnotes 1 and 2 on page 45.

and condition [4-27] implies that [4-30] will hold for any refiner bound by the regulations.

For the regulated equilibrium price to be less than marginal cost, the left-hand side of [4-29] must be greater than $\overline{P}$. This is a possible but not inevitable situation.

The long-run choices in the single-product monopoly model would be determined essentially as in the price-taker model. The input mix of a constrained firm would be distorted toward an inefficiently low capital to crude oil ratio, as condition [2-16] would also be the relevant profit-maximizing condition for a monopolist. Also, the long-run profit function and profit-maximizing output conditions for the price-taker shown in [2-21] and [2-22] are valid for the firm with market power.[1]

The implication that the firm may select a lower level of capital and a lower long-run output because of the regulations is thus unaltered. It follows, therefore, that the conclusion that the regulated price may be higher than the unregulated price is valid whether the industry is competitive or noncompetitive.

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[1] There is a difference in the construction of the long-run "cost" functions for the firm with market power. Whereas the price-taker had a factor mix (FM) curve for each possible market clearing price, the firm with market power will have a single FM curve because he determines the market clearing price with his output. The FM curve will pass through the single point on each isoquant at which the ceiling price equals the market clearing price for the relevant output.

The Partial Decontrol Model

If the market clearing price of the regulated product ($\bar{P}m$) is made a function of the firm's volume ($Vm=GVr+Vp$) in the model of chapter III, the first order conditions change only by the addition of the term $\lambda_2(\partial\bar{P}m/\partial Vm)$ to $\partial L/\partial Vr$ and $\partial L/\partial Vp$ shown in [3-10] and [3-11].

The condition under which the monopolist refiner will be unconstrained is shown by [3-15] as it was for the price-taker; and the market clearance proof is unaltered from that in the price-taker model because $\lambda_2$ is set equal to zero in that proof.

The proof that the constrained, integrated monopolist will retail a greater volume of gasoline than he would in the absence of regulation proceeds just as it did for the price-taker. The first order condition for the unregulated monopolist that is analogous to [3-18] is

[4-31] $(\partial L/\partial Vp)^* = \bar{P}m + Vm(\partial\bar{P}m/\partial Vm) - Pp - (\partial Am/\partial Vm)^* = 0,$

when the response of price to output is included. For the constrained monopolist,

[4-32] $$(\partial L/\partial Vp) = \bar{P}m - Pp - \frac{\partial Am}{\partial Vm} + \lambda_1\frac{\partial Zm}{\partial Vp} + \lambda_2\frac{\partial\bar{P}m}{\partial Vm} = 0,$$

as pointed out above. Therefore, noting from [3-12] (which is valid for the monopolist) that $\lambda_2 = Vm-\lambda_1$, the condition analogous

to [3-19] for the firm with market power is

$$[4\text{-}33] \quad (\partial L/\partial Vp) = \bar{P}m + Vm\frac{\partial \bar{P}m}{\partial Vm} - Pp - \frac{\partial Am}{\partial Vm} + \lambda 1\left(\frac{\partial Zm}{\partial Vp} - \frac{\partial \bar{P}m}{\partial Vm}\right) = 0.$$

Also, since the only change in $\partial L/\partial Vp$ was the addition of $\lambda 2(\partial \bar{P}m/\partial Vm)$, the condition for the constrained monopolist that is analogous to [3-20] is

$$[4\text{-}34] \quad \partial L/\partial Vp = Pm^{\circ} - Pp^{\circ} - Xm^{\circ} - \lambda 2\left(\frac{\partial Zm}{\partial Vp} - \frac{\partial \bar{P}m}{\partial Vm}\right) = 0.$$

Since it is assumed that $Pm^{\circ}-Pp^{\circ}-Xm^{\circ}>0$, and since $\lambda 1>0$ and $\lambda 2>0$ for the constrained firm, it follows from [4-34] that $\partial Am/\partial Vp$ is greater in [4-32] than in [4-31]; thus the retail volume of the firm is greater with regulation.[1]

The proof that the constrained firm with market power may have a smaller refinery output due to the regulations (even in the short run) also proceeds just as it did for the price-taker. The

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1 Note that the constrained firm will sell below marginal cost only if

$$\lambda 1\frac{\partial Zm}{\partial Vp} + \lambda 2\frac{\partial \bar{P}m}{\partial Vm} > 0,$$

which will not necessarily be the case. This leads to the ambiguous efficiency and social welfare effects (discussed above) of the displacement of independent marketers by the increased output of the constrained integrated marketers who have market power.

condition analogous to [3-25] for the regulated monopolist is

$$[4\text{-}35] \quad \left(\frac{\partial L}{\partial Vr}\right)^* = GPp + (1-G)Pu - \left(\frac{\partial Ar}{\partial Vr}\right)^* = 0,$$

and the condition analogous to [3-26] for the constrained regulated monopolist is

$$[4\text{-}36] \quad \left(\frac{\partial L}{\partial Vr}\right) = GPp + (1-G)Pu - \frac{\partial Ar}{\partial Vr} + \lambda_1\left[\frac{\partial Zm}{\partial Vr} - G\frac{\partial Zm}{\partial V_p}\right] - 0.$$

Therefore, the condition for the constrained monopolist's refinery output to be lower than it would be in the absence of regulation (analogous to [3-27] for the price-taker) is

$$[4\text{-}37] \quad \frac{\partial Zm}{\partial Vr} - G\frac{\partial Zm}{\partial Vp} < 0.$$

Condition [4-37] translates to

$$[4\text{-}38] \quad G(Pp^\circ - Xr^\circ) + (1-G)Pu - (1-G)(\partial Ar/\partial Vr) < 0,$$

which is precisely the same condition (see [3-31]) under which the price-taker would refine a lower volume in the short run due to the regulations.[1]

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[1] The explanation for this result is the same for the monopolist as it was for the price-taker. In fact, the expression in [3-32] is valid for the firm with market power, since it is generated with $\lambda_2 = 0$.

As with the single product model, the input ratio and long-run output analysis are essentially the same for the partially decontrolled firm with market power as for the price-taker. The algebra of the output mix analysis is altered somewhat, but the changes do not significantly affect any conclusions.

## Chapter V

## MULTIPLE CEILING PRICES

Refiners incur different costs when they sell gasoline in different economic markets. For example, they generally incur higher costs when they sell at retail rather than wholesale or when they sell at a remote location rather than a location to which transportation costs are low. The regulations allow sellers, within limits, to have a different ceiling price for each "class of purchaser," to reflect the fact that some types of sales involve a higher cost than others.[1]

To examine the effect of multiple ceiling prices, this chapter analyzes the behavior of a refiner who sells gasoline at two functional levels, wholesale and retail. Such a refiner will be referred to as partly integrated. It is shown that the method of calculating the ceiling prices for sales at different functional levels induces a constrained refiner to sell product farther downstream than is efficient. That is, the controls induce refiners to sell gasoline through their own retail outlets that they would sell to nonaffiliated retailers in the absence of controls. This will occur even though the marginal cost of performing the retailing function is greater for the constrained refiner than for the nonaffiliated marketers.

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[1] The limits on differences between a seller's ceiling prices were imposed by the "equal application rule." That rule was suspended on November 1, 1980, after the analysis of this report was completed.

Although the analysis of this chapter focuses on a refiner that sells product in different functional markets presumed to be in a single retail market area, the analysis is also applicable to refiners serving purchasers in different geographic markets. In that case, the different functional levels in the distribution system would be interpreted as different locations. The incentive to sell gasoline inefficiently far downstream is, in its broadest sense, an incentive to sell inefficiently large gasoline volumes where base period prices were the highest. Whether these prices were high due to functional, locational, or other differentials makes little difference.

This incentive has two adverse effects on gasoline marketing and distribution. First, it leads directly to an increase in the cost of marketing and distribution by inducing the constrained refiner to make inefficient choices as to the functional level (or geographic location) at which he sells gasoline. Second, it has anticompetitive effects on independent marketers which are customers of constrained refiners. These effects are similar to the anticompetitive effects described in chapter III.

CLASS-OF-PURCHASER CEILING PRICES

The key element in understanding how the DOE price controls provide for price differentials among various types of customers is the "classes of purchaser" into which each refiner is required to group its sales. These classes of purchaser are supposed to be established so as to preserve traditional price differentials among different types of customers. The regulations define a

"class of purchaser" to mean "purchasers to whom a person has charged a comparable price for comparable property or service pursuant to customary price differentials between those purchasers and other purchasers."[1] It is important to recognize, however, that a class of purchaser is generally not defined to include particular firms but to include particular types of transactions. Separate classes of purchaser might be established for sales at different locations, sales in different volumes, and sales with different terms. Thus, a single firm might buy gasoline as a member of more than one class of purchaser if it engaged in more than one type of transaction.

The analysis in this chapter abstracts from the multitude of problems inherent in even good-faith efforts to define appropriate classes of purchaser by assuming that the refiner designates only two classes, wholesale and retail, and that all sales are correctly classified.[2]

The ceiling price to each class of purchaser is determined by adding increased average allowable costs equally to the base

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1 See U.S. Department of Energy, Federal Energy Guidelines, pp. 13,821.14. Since these classes of purchaser are fundamental to the regulations, they are also addressed in several DOE rulings, particularly 1975-2.

2 The concept of class of purchaser is sufficiently imprecise that refiners in practice seem to have considerable discretion in deciding what should constitute a class of purchaser. Apparently, while some refiners have chosen to treat virtually every customer as a separate class of purchaser (and DOE has apparently approved such a procedure in at least some instances), others have chosen to use only a handful of very broad classes of purchaser.

period price for each class.[1,2] Thus, the refiner's ceiling price for the class of purchaser designated i is

[5-1] $Zi = Pi^\circ + Y$,

where i (under the assumptions of this chapter) is either

w: designating wholesale sales, or

m: designating retail sales,

and where

$Pi^\circ$: average price (weighted by volume) charged by the refiner to the ith class of purchaser on May 15, 1973

Y: increased allowable cost, defined as

$$[5\text{-}2]\quad Y = \left[\left(\frac{GVr}{GVr + Vp}\right)\left(\frac{Ar+Nr}{Vr} - \frac{Ar^\circ+Nr^\circ}{Vr^\circ}\right)\right] + \left[\left(\frac{Vp}{GVr+Vp}\right)(Pp-Pp^\circ)\right] + \left[\frac{Aw+Nw+Am+Nm}{Vs} - \frac{Aw^\circ+Nw^\circ+Am^\circ+Nm^\circ}{Vs^\circ}\right],$$

where

$Vs = Vm+Vw$: the total volume sold to all classes of purchaser

Am and Nm: are the total allowable nonproduct marketing costs (variable and capital respectively) associated with retail sales

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1 This formulation of the ceiling price omits the "retail price adjustment" exception. That exception is omitted for simplicity, because it does not directly affect the key result of this chapter, the refiner's incentive to sell gasoline further downstream. The retail price exception is discussed briefly at the end of this chapter.

2 The suspension of the equal application rule, which occurred after this analysis was completed, removed any requirement that cost increases be added equally to each class of purchaser price. The suspension of the equal application rule changes the Y in [5-1] to Yi and the Y in [5-2] to the weighted average Yi. However, the incentive identified below for the refiner inefficiently to increase the proportion of retail sales still exists.

Aw and Nw: are the total allowable nonproduct marketing costs (variable and capital respectively) associated with wholesale activities.

All other symbols have been previously defined. As before, all variables are specific to the individual refiner, and the superscript ° designates base period values.

Increased allowable cost is defined in generally the same way as in the previous chapter, although its formulation is complicated slightly because sales occur at different functional levels. The first two bracketed expressions in [5-2] are the increased cost of refining and the increased cost of purchased product, both of which are calculated just as in chapter III. The third bracketed expression is increased marketing nonproduct cost. The level of this cost both in the current period and the base period is computed by dividing the sum of allowable marketing costs at all levels of the marketing and distribution network by total sales volume at all levels of the network. Increased allowable marketing cost is then the difference between these two ratios.[1,2]

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1 There is a per-gallon upper limit on the increased marketing nonproduct cost that may be passed through. This limitation is considered in chapter VI.

2 This method of calculating increased marketing nonproduct costs applies only to integrated refiner-marketers. While the same cost pass-through regulations technically applied to both integrated and unintegrated marketers, prior to December 1978, DOE in practice assumed that the allowable marketing costs of all but the very largest unintegrated marketers had increased by 3 cents per gallon. Smaller marketers were therefore not required to justify these increased marketing costs. In December 1978, DOE also

(footnote continues on next page)

INCENTIVE TO SELL INEFFICIENTLY FAR DOWNSTREAM

The effect of the regulations on a partly integrated refiner can be shown most precisely in the context of a complete mathematical model, and this is done below. However, the source of the tendency for the refiner to sell inefficiently far downstream can be seen in the ceiling price formulas. The incentive arises because the ceiling price formulas do not distinguish between increases in the average cost of performing a particular function and increases in the firm's overall average cost due to its making a greater proportion of sales downstream. For example, if a refiner switches a gallon of his sales from the wholesale level to the retail level, he will incur higher costs, because he performs the retail function and delivers the gasoline all the way to the final consumer rather than just delivering it to a retail outlet. The increased allowable cost term (Y) in the ceiling price formulas will increase enough for the refiner to pass through all of those added costs.[1] In addition, however, the transferred gallon can be sold under the retail rather than wholesale ceiling price; and the retail ceiling price formula incorporates a higher

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(footnote continued)
permitted unintegrated marketers to further raise their selling prices to reflect subsequent increases in the cost of mandated vapor recovery systems. Then in July of 1979, the regulations were further altered to permit unintegrated retailers to charge the cost of product plus 15.4 cents per gallon. This limit has subsequently been increased.

1 To the extent they are allowable. If any additional equity cost of capital were incurred, it could not be recovered.

base period price. It contains the base period retail price, which would, of course, be higher than the base period wholesale price. As a result, the refiner can more than recover cost increases incurred when sales are shifted farther downstream.

It is probable that the different base period prices incorporated in the class of purchaser ceiling price formulas were supposed to correct for the differing costs of selling at different functional levels; and the increased allowable cost portion (the Y factor) was supposed to compensate for inflation in the cost of doing business within particular functions. This might be a reasonable approach for a short period of regulation within which refiners could not substantially alter the composition of their sales.[1] (The formulas at least have the great virtue of simplicity.) However, problems arise when refiners are able to make changes in the proportion of sales made to various classes of purchaser. The difficulty of formulating a better regulation in this regard is discussed at the conclusion of this chapter.

THE MODEL

In the formal model of this chapter, it is assumed that refiners may sell gasoline either at wholesale (e.g., dealer tank wagon), or at retail. It is also assumed that gasoline at each

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[1] However, even if the pricing rule did not give refiners the incentive to systematically alter the distribution of their sales toward downstream classes of purchaser, the fact that the price rules tend to reflect average cost rather than marginal cost would still cause an inefficient distribution of sales, as discussed in earlier chapters.

functional level is homogeneous, that there are no economies o diseconomies of operating multiple retail or wholesale outlets that the outlets of each refiner are located in the same marke and sell only gasoline, and that all outlets of each type sel gasoline at the same price and have the same cost function.[1]

Most refiners will, of course, make more than two types o gasoline sales at more than two prices. These two types of sales however, are sufficient to capture the regulatory effects con sidered in this chapter. The use of more than two types of sale would only add needless complexity.

The profits of the partly integrated refiner can be written:

[5-3] $\Pi = VmPm + VwPw + Vr(1-G)Pu - Ar - Nr - Rr - Aw - Nw - Rw - Am - Nm - Rm - VpPp,$

where all values are defined as in chapters II and III except fo the addition of the subscripts w and m to designate wholesale an retail variables, respectively.

The relationship assumed among the marketing costs require explanation. The costs incurred in selling gasoline at wholesal are the wholesale marketing costs (Aw, Nw, and Rw); and the addi tional costs incurred in selling product retail instead of whole sale are the retail marketing costs (Am, Nm, and Rm). Retai sales are assumed to incur the same wholesaling costs as wholesal

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1 The assumptions of chapters II and III, that refiners ar price-takers, that they carry no inventories of crude oil nor o refined product, that they have no banked costs, and that there i no time lag in the cost pass-through, are maintained.

sales. Thus, total wholesaling costs are determined by the level of wholesale plus retail sales and $(\partial Aw/\partial Vw) = (\partial Aw/\partial Vm)$.

A final simplifying assumption is made concerning differences in the market clearing prices at various functional levels. The fact that the ceiling price formula allocates increased marketing costs equally to each class of purchaser implies that the differences between any two class-of-purchaser ceiling prices is fixed and equal to the difference between the base period prices for those classes of purchaser. Thus, if the current market clearing price level of the various class-of-purchaser prices is such that the differences between them have changed since the base period, a refiner will be unable to simultaneously equate all of his class-of-purchaser ceiling prices to the relevant market clearing prices. To abstract from this complicating feature of the regulations, it is initially assumed that differences between the market clearing prices for various classes of purchasers in the current period are the same as the differences in the base period.[1]

With these simplifying assumptions, the refiner's objective is to maximize profits, subject to the following restrictions of his choice prices, Pi:

[5-4] $Pm \leq \overline{P}m$

[5-5] $Pw \leq \overline{P}w = \overline{P}m - (Pm^{\circ} - Pw^{\circ})$

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[1] The consequences of relaxing this assumption are treated briefly at the end of this chapter and are discussed in detail in chapter VII.

[5-6] $Pm \leq Zm$

[5-7] $Pw \leq Zw = Zm - (Pm^{\circ} - Pw^{\circ})$,

where $\overline{P}i$ is the market clearing price for class of purchaser i. The equality conditions in [5-5] and [5-7] are shown for future reference. That in [5-5] follows from the assumption above that differences between various class-of-purchaser prices have not changed since the base period. The equality in [5-7] follows from the ceiling price formula in [5-1].

The relevant Lagrangian function for this refiner is[1]

[5-8] $L = \Pi + \lambda_{1m}(Zm-Pm) + \lambda_{2m}(\overline{P}m-Pm) + \lambda_{1w}(Zw-Pw) + \lambda_{2w}(\overline{P}w-Pw)$
$+ \lambda_3(GVr+Vp-Vm-Vw).$

The analysis will be short-run in that the refiner's capital stock and gasoline fraction are assumed to be fixed and the same as in the absence of controls.[2] The refiner's choice variables are therefore Vr, Vp, Vw, Vm, Pw, and Pm.[3]

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[1] The $\lambda_3$ constraint was incorporated implicitly in preceding models by defining one of the quantity choice variables in terms of the others. However, in analyzing this model it is preferable to explicitly incorporate this restriction as a constraint.

[2] The long-run input and output choice problems are not considered in this chapter. Although the long-run maximization problem of the partly integrated refiner is somewhat different from that considered in chapter III, the discussion would be largely redundant.

[3] Since the capital stock is assumed to be fixed, the various cost functions can be expressed as functions of volume alone. Thus, $Ar = Ar(Vr)$, $Aw = Aw(Vw + Vm)$, and $Am = Am(Vm)$.

Assuming that the equlibrium values of all choice variables are greater than zero,[1] the necessary conditions for profit maximization are

$$[5\text{-}9] \quad \frac{\partial L}{\partial Vw} = Pw - \frac{\partial Aw}{\partial Vw} + \lambda_{1m} \frac{\partial Zm}{\partial Vw} + \lambda_{1w} \frac{\partial Zw}{\partial Vw} - \lambda_3 = 0$$

$$[5\text{-}10] \quad \frac{\partial L}{\partial Vm} = Pm - \frac{\partial Aw}{\partial Vm} - \frac{\partial Am}{\partial Vm} + \lambda_{1m} \frac{\partial Zm}{\partial Vm} + \lambda_{1w} \frac{\partial Zw}{\partial Vm} - \lambda_3 = 0$$

$$[5\text{-}11] \quad \frac{\partial L}{\partial Vr} = Pu(1-G) - \frac{\partial Ar}{\partial Vr} + \lambda_{1m} \frac{\partial Zm}{\partial Vr} + \lambda_{1w} \frac{\partial Zw}{\partial Vr} + G\lambda_3 = 0$$

$$[5\text{-}12] \quad \frac{\partial L}{\partial Vp} = -Pp + \lambda_{1m} \frac{\partial Zm}{\partial Vp} + \lambda_{1w} \frac{\partial Zw}{\partial Vp} + \lambda_3 = 0$$

$$[5\text{-}13] \quad \frac{\partial L}{\partial Pw} = Vw - \lambda_{1w} - \lambda_{2w} = 0$$

$$[5\text{-}14] \quad \frac{\partial L}{\partial Pm} = Vm - \lambda_{1m} - \lambda_{2m} = 0$$

$$[5\text{-}15] \quad \lambda_{1m} \left(\frac{\partial L}{\partial \lambda_{1m}}\right) = \lambda_{1m} (Zm-Pm) = 0$$

$$[5\text{-}16] \quad \lambda_{2m} \left(\frac{\partial L}{\partial \lambda_{2m}}\right) = \lambda_{2m} (\bar{P}m-Pm) = 0$$

$$[5\text{-}17] \quad \lambda_{1w} \left(\frac{\partial L}{\partial \lambda_{1w}}\right) = \lambda_{1w} (Zw-Pw) = 0$$

$$[5\text{-}18] \quad \lambda_{2w} \left(\frac{\partial L}{\partial \lambda_{2w}}\right) = \lambda_{2w} (\bar{P}w-Pw) = 0$$

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[1] The assumption that the refiner sells all of the gasoline that he acquires implies that $\lambda_3 > 0$.

[5-19] $\frac{\partial L}{\partial \lambda 3} = GVr + Vp - Vw - Vm = 0$

along with [5-4] through [5-7].

In the section below it is shown that the constrained refi will generally find it profitable to equate his ceiling price the market clearing price. In the following section, the inef cient distribution of activity among functional levels is sh rigorously. Specifically it is shown that given the wholes and retail market prices, the refiner is induced to sell too m gasoline retail relative to the amount sold at wholesale. It also shown that given the retail price and the price of purcha product, the level of retail sales of the constrained partly in grated refiner is inefficiently high in absolute terms while level of wholesale sales is likely to be inefficiently l Finally, the ramifications of relaxing the assumption ab unchanged differences in class-of-purchaser market clearing pri are discussed.

EQUILIBRIA AND MARKET CLEARANCE

As in previous chapters, it is useful to categorize the p sible equilibria of the model based on the solution values of Lagrangian multipliers. In this case, the three categories u are

Type A: $\lambda 1m = 0$

Type B: $\lambda 1m > 0$, $\lambda 2m = 0$

Type C: $\lambda 1m > 0$, $\lambda 2m > 0$.

Each is discussed in sequence below.

Type A: $\lambda_{1m} = 0$. If $\lambda_{1m}$ equals zero, the price controls are not binding for retail sales. It can be seen from [5-14] that if $\lambda_{1m} = 0$, then $\lambda_{2m} > 0$. Equation [5-16] then shows that the refiner will charge retail customers the market clearing price. Given [5-5] and [5-7], $\lambda_{1m} = 0$ also implies $\lambda_{1w} = 0$.[1] $\lambda_{1w} = 0$, in turn, implies that the price controls are not binding on wholesale sales and (from [5-13] and [5-18]) that the refiner will also charge wholesale customers the market clearing price.

The refiner in this case is able to select all variables to maximize profits as if there were no price regulation, because the profit-maximizing choice results in ceiling prices that exceed the market clearing prices. Therefore, if $\lambda_{1m} = \lambda_{1w} = 0$, equations [5-9] through [5-19] also describe the profit-maximizing conditions for an unregulated refiner; and equations [5-9] and

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[1] This relationship will hold if it is assumed that if $\lambda_{1i} = 0$, then $Zi > Pi$. In that case, the knowledge that $\lambda_{1m} = 0$ and $\bar{P}m = Pm$ coupled with [5-15] implies that $Zm > \bar{P}m$. Conditions [5-5] and [5-7] then imply $Zw > \bar{P}w$; and this, coupled with [5-17], implies $\lambda_{1w} = 0$.

As noted in chapter II, it could be the case that $Zi = Pi$ for $\lambda_{1i} = 0$ or that $\bar{P}i = Pi$ for $\lambda_{2i} = 0$. However, these possibilities are ignored because recognition of them would only confuse the exposition with no effect on the results. The interested reader who wishes to prove the irrelevance of these possibilities will find it helpful to categorize the equilibria as follows: type A, $\lambda_{1m} = \lambda_{1w} = 0$; type B, $\lambda_{2m} = \lambda_{2w} = 0$; and type C, $\lambda_{1m} + \lambda_{1w} > 0$ and $\lambda_{2m} + \lambda_{2w} > 0$.

[5-10] may be rewritten to describe the equilibrium conditions of the unregulated refiner as follows:[1]

[5-20] $\bar{P}w - Pp - (\partial Aw/\partial Vw) = 0$

[5-21] $\bar{P}m - Pp - (\partial Aw/\partial Vm) - (\partial Am/\partial Vm) = 0.$

Type B: $\lambda_{1m} > 0, \lambda_{2m} = 0$. In this type of equilibrium the refiner is constrained and markets would not clear. Since $\lambda_{1m} >$ 0, the refiner is constrained to set his retail price equal to his retail ceiling price. At the same time, $\lambda_{2m} = 0$ implies that his retail ceiling price lies below the market clearing price. Given [5-5] and [5-7], $\lambda_{1m} > 0$ and $\lambda_{2m} = 0$ imply that $\lambda_{1w} > 0$ and $\lambda_{2w} =$ 0[2] and thus that the same equilibrium prevails in the wholesale market.

While this type of equilibrium could in principle occur, the values of certain variables are normally such that it will not. To show this, note that if $\lambda_{1i} > 0$ and $\lambda_{2i} = 0$, conditions [5-9] and [5-10] are equivalent to:[3]

[5-22] $\frac{\partial L}{\partial Vw} = Pw^{\circ} - Pp^{\circ} - Xs^{\circ} = 0$

[5-23] $\frac{\partial L}{\partial Vm} = Pm^{\circ} - Pp^{\circ} - Xs^{\circ} = 0,$

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1 If $\lambda_{1m} = \lambda_{1w} = 0$, then $\bar{P}w = Pw$ and $\bar{P}m = Pm$ as pointed out above, and equation [5-12] implies that $\lambda_3 = Pp$. This information is then used to simplify equations [5-9] and [5-10].

2 Since $\lambda_{1m} > 0$ implies $Pm = Zm$ and $\lambda_{2m} = 0$ implies $Pm < \bar{P}m$, it follows that $Zm < \bar{P}m$. Conditions [5-5] and [5-7] then imply $Pw < \bar{P}w$. Thus, from [5-18] $\lambda_{2w} = 0$, and then from [5-13] $\lambda_{1w} > 0$.

3 Conditions [5-22] and [5-23] can be derived as follows: If $\lambda_{2i}=0$, then by conditions [5-13] and [5-14], $\lambda_{1w}=Vw$ and $\lambda_{1m}=Vm$.

(footnote continues on next page)

where

$$Xs^\circ = \frac{Am^\circ + Nm^\circ + Aw^\circ + Nw^\circ}{Vs^\circ}$$

Since $Xs^\circ$ does not refer to the average allowable costs of any particular type of transaction, it is convenient to rewrite condition [5-23] for purposes of interpretation as:

[5-24] $$\frac{\partial L}{\partial Vm} = [Pm^\circ - Pp^\circ - Xw^\circ - Xm^\circ] + Xm^\circ \left[\frac{Vw^\circ}{Vs^\circ}\right],$$

where $Xw^\circ = \frac{Aw^\circ + Nw^\circ}{Vw^\circ + Vm^\circ}$ and $Xm^\circ = \frac{Am^\circ + Nm^\circ}{Vm^\circ}$.

The first of the bracketed expressions in equation [5-24] corresponds to the accounting profit per unit of retail sales in the base period. This would normally be positive. Since the

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(footnote continued)
Thus $\lambda_{1w} + \lambda_{1m} = Vs$. As noted above, $\lambda_{1i} > 0$ implies $Pi = Zi$. Substitute this information and the expression for $\lambda_3$ implicit in [5-12] into [5-9] and [5-10] to get (for i= m or w)

$$\frac{\partial L}{\partial Vi} = Zi - Pp - \frac{\partial Aw}{\partial Vi} - \frac{\partial Am}{\partial Vi} + Vs\left(\frac{\partial Zi}{\partial Vi} + \frac{\partial Zi}{\partial Vp}\right) = 0.$$

This expression can be simplified to yield [5-22] and [5-23] by noting that Zi can be written

$$Zi = Pi^\circ + (Pp - Pp^\circ) + \frac{GVr}{GVr+Vp}\left[\frac{Ar+Nr}{Vr} - \frac{Ar^\circ+Nr^\circ}{Vr^\circ} - (Pp - Pp^\circ)\right] + Xs - Xs^\circ;$$

that (for j = m or w)

$$\frac{\partial Zj}{\partial Vp} = \frac{GVr}{(Vs)^2}\left[Pp - Pp^\circ - \left(\frac{Ar+Nr}{Vr} - \frac{Ar^\circ+Nr^\circ}{Vr^\circ}\right)\right];$$

and that

$$\frac{\partial Zj}{\partial Vi} = \frac{1}{Vs}\left(\frac{\partial Aw}{\partial Vi} + \frac{\partial Am}{\partial Vi} - Xs\right).$$

second term in brackets will be nonnegative, the entire expression will generally have a value greater than zero, thus ruling out the type B equilibria as profit maximizing. So long as the refiner's ceiling price is below the market clearing price, the refiner will be able to expand his sales volume and recoup any additional costs plus a profit margin by increasing his ceiling price. Thus, the volume that yields the type B solution is not profit maximizing.

Although this equilibrium will not exist for a firm for which positive output is profitable, an examination of [5-22] and [5-23] provides further intuition into the incentive for the partly integrated refiner to sell gasoline farther downstream. It is apparent that these equations can only be simultaneously satisfied if $\partial L/\partial Vm = \partial L/\partial Vw$, which would generally be impossible, because $Pm^{\circ}$ would be greater than $Pw^{\circ}$. This highlights the fact that if a refiner sells gasoline at retail instead of wholesale, he not only recoups his increased marketing costs, he also recoups the difference in the base period prices for the two transactions. Thus, absent a market price constraint, refiners in this model would sell all of their gasoline at retail, since the base period retail price will almost always be higher than the base period wholesale price.

Type C: $\lambda_{1m} > 0$, $\lambda_{2m} > 0$. In this equilibrium, the partly integrated refiner is constrained by the controls but finds it profitable to equate his retail ceiling price to the retail market price. From [5-15] and [5-16] it can be seen that if $\lambda_{1m} > 0$ and

$Z_m > 0$, then $P_m = \bar{P}_m = Z_m$. If $\bar{P}_m = Z_m$, [5-5] and [5-7] imply that $\bar{P}_w = Z_w$. Therefore, this equilibrium is characterized by no excess demand for gasoline in either the retail or wholesale markets. All constrained refiners with a positive base period margin on retail sales (expression [5-24] is greater than zero) will be in this type of equilibrium. Since equation [5-24] is expected to be typically positive, this equilibrium is the likely equilibrium for most constrained firms, and the following analysis of regulatory effects is conducted under the assumption that type 1 equilibrium prevails.

SALES AT VARIOUS FUNCTIONAL LEVELS

The controls will induce a constrained refiner to select an inefficiently high level of retail sales relative to wholesale sales given the retail and wholesale market prices. The controls will also induce the refiner to select an inefficiently high level of retail sales in absolute terms, given the market prices he confronts. Finally, the controls will in certain circumstances induce the refiner to select an inefficiently low level of wholesale sales in absolute terms given the market prices he confronts and may induce the refiner to completely eliminate these sales.

These results can be derived from the necessary condi for profit maximization. Assuming the type C equilibrium, can be written[1]

$$[5\text{-}25]\quad \frac{\partial L}{\partial Vw} = \bar{P}w - Pp - \frac{\partial Aw}{\partial Vw} + (\lambda_{1w}+\lambda_{1m})\left(\frac{\partial Zm}{\partial Vw} + \frac{\partial Zm}{\partial Vp}\right) = 0$$

$$[5\text{-}26]\quad \frac{\partial L}{\partial Vm} = \bar{P}m - Pp - \frac{\partial Aw}{\partial Vm} - \frac{\partial Am}{\partial Vm} + (\lambda_{1w}+\lambda_{1m})\left(\frac{\partial Zm}{\partial Vm} + \frac{\partial Zm}{\partial Vp}\right) = 0.$$

These conditions can also be written

$$[5\text{-}27]\quad \frac{\partial L}{\partial Vw} = Pw^{\circ} - Pp^{\circ} - Xs^{\circ} - (\lambda_{2w}+\lambda_{2m})\left(\frac{\partial Zm}{\partial Vw} + \frac{\partial Zm}{\partial Vp}\right) = 0$$

$$[5\text{-}28]\quad \frac{\partial L}{\partial Vm} = Pm^{\circ} - Pp^{\circ} - Xs^{\circ} - (\lambda_{2w}+\lambda_{2m})\left(\frac{\partial Zm}{\partial Vm} + \frac{\partial Zm}{\partial Vp}\right) = 0.$$

The first result, that refiners will choose an ineffici high level of retail as opposed to wholesale sales given m prices, is derived by observing that in equilibrium the mar profitability of selling a gallon of gasoline retail inste wholesale must be zero (i.e., $\partial L/\partial Vw = \partial L/\partial Vm$). Equations [ and [5-26], therefore, require that in equilibrium (since $\partial Z$ $- \partial Zm/\partial Vw = (1/Vs)(\partial Am/\partial Vm)$)

$$[5\text{-}29]\quad \bar{P}m - \bar{P}w - \frac{\partial Am}{\partial Vm} + (\lambda_{1w}+\lambda_{1m})\left(\frac{1}{Vs}\right)\left(\frac{\partial Am}{\partial Vm}\right) = 0.$$

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[1] Conditions [5-25] and [5-26] are derived from equations through [5-19] by noting that $Pi=Zi=\bar{P}i$; and that $\partial Zm/\partial Vp=\partial Zw/\partial Vp$, by equation [5-12], $\lambda_3=Pp-(\lambda_{1w}+\lambda_{1m})(\partial Zm/$ Conditions [5-27] and [5-28] are derived just as [5-22] an 23], except in this case, $(\lambda_{1w}+\lambda_{1m})=Vs-(\lambda_{2w}+\lambda_{2m})$.

Since $\lambda_{1i} > 0$, the marginal cost of selling gasoline retail instead of wholesale in the regulated equilibrium will exceed the difference between the retail and wholesale prices. This is in contrast to the exact equality between marginal cost and the price differential in the unregulated equilibrium.[1] This implies that given the retail and wholesale prices too much will be sold retail, rather than wholesale, in the regulated equilibrium.

The second result, that given current prices the absolute level of retail sales is inefficiently high, requires that

[5-30] $Pm^{\circ} - Pp^{\circ} - Xs^{\circ} > 0.$

As shown in the discussion of equation [5-24] above, this expression will always be positive, provided the refiner's base period margin on retail sales was positive. Equations [5-28] and [5-30] then imply that $\partial Zm/\partial Vm + \partial Zm/\partial Vp > 0$. Equation [5-26] in turn implies that in the regulated equilibrium,

[5-31] $\overline{Pm} < Pp + \partial Aw/\partial Vm + \partial Am/\partial Vm.$

Thus, the retail price of gasoline ($\overline{Pm}$) is less than the marginal cost of selling another gallon; and given market prices the level of retail sales is inefficiently high.

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1 See equations [5-20] and [5-21] above.

The third result is that given current prices the absolute level of wholesale sales will be inefficiently low in the regulated equilibrium, provided

[5-32] $Pw^{\circ} - Pp^{\circ} - Xs^{\circ} < 0.$

While equation [5-32] is not necessarily valid, it is plausible for refiners with nontrival retail sales in the base period. Since $Xs^{\circ}$ is the average allowable marketing cost of all sales in the base period, it must be greater than the average allowable cost of wholesale sales in the base period. Thus, even if wholesale sales earned an accounting profit in the base period, the base period margin ([5-32] may be negative because of the inclusion ot base period retailing costs in average base period allowable marketing cost ($Xs^{\circ}$).[1]

If condition [5-32] is valid, then equation [5-27] implies that in equilibrium,

[5-33] $$\frac{\partial Z_m}{\partial Vw} + \frac{\partial Zm}{\partial Vp} < 0.$$

This in turn implies, in conjunction with equation [5-25], that

[5-34] $$\overline{Pw} > Pp + \frac{\partial Aw}{\partial Vw}.$$

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1 This is evident if condition [5-32] is rewritten $Pw^{\circ} - Pp^{\circ} - Xw^{\circ} - Xm^{\circ} \frac{Vm^{\circ}}{Vs^{\circ}} < 0.$

Thus, wholesale price ($\bar{P}w$) is higher than the marginal cost of selling an additional gallon at wholesale; and therefore, given market prices, the level of wholesale sales is inefficiently low.

It is possible that a refiner will eliminate wholesale sales all together. If equation [5-32] holds, it has just been shown that the equilibrium condition for nonzero wholesale sales is [5-34].[1] However, the marginal cost of wholesale sales ($\partial Aw/\partial Vm$) depends not only on the level of wholesale sales but also on the level of retail sales. Thus it may be that

$$[5\text{-}35] \quad \frac{\partial Aw}{\partial Vw} > \bar{P}w - Pp$$

at $Vw = 0$. In that case no sales will occur at wholesale.

CHANGES IN MARKET PRICE DIFFERENTIALS

The results above have been derived under several simplifying assumptions. Probably the least plausible of these is the assumption that the current differences between the market clearing prices for various classes of purchaser are equal to the differences in the base period prices for those classes of purchaser. While this assumption does simplify the analysis, identical results can be derived with somewhat looser assumptions regarding changes in price differences since the base period. The model employed above omits a potentially important provision of the

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1 In deriving [5-25] and [5-29] upon which [5-34] is based, it was assumed that Vw was nonzero.

regulations that increases refiner pricing flexibility--the retail price adjustment exception to the equal application rule.

The equal application rule requires that the ceiling price for each class of purchaser be computed by adding the same increased average cost figure to each class's base period price. That rule yields the ceiling price constraints used above,

[5-36] $Pi \leq Zi = Pi^{\circ} + Y$.

The retail price adjustment exception to the equal application rule permits the refiner, if he so desires, to pass through more of his increased marketing nonproduct costs on his retail sales than on his nonretail sales.[1] Under this exception, the ceiling price constraints become

[5-37] $Pm \leq Zm = Pm^{\circ} + Y + J - \frac{JVm}{Vs}$

[5-38] $Pw \leq Zw = Pw^{\circ} + Y - \frac{JVm}{Vs}$,

where J is the retail price adjustment factors.

Since this provision only allows the reallocation of increased costs, it does not affect the amount of total increased

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1 This retail price adjustment was originally limited to a maximum of 3 cents per gallon. The limit was subsequently raised to 8.6 cents per gallon and now moves up with inflation.

It should also be noted that if the refiner sells to more than one nonretail class of purchaser, he must add the same amount to each of their base period prices to compute their ceiling prices.

costs that the regulations allow to be recouped. The exception does, however, allow some flexibility in the difference between class of purchaser ceiling prices. This difference in ceiling prices with the retail exception is

[5-38] $Zm - Zw = Pm^{\circ} - Pw^{\circ} + J$.

Because J is a choice variable, the relationship between the current and base period margins is less important than suggested previously. The assumption employed in the model above, that there has been no change since the base period in the differences between class of purchaser equilibrium prices, can be relaxed somewhat without affecting the results obtained. If the refiner sells gasoline to only two classes of purchaser, retail and wholesale, it need only be assumed that the current equilibrium price differential is no less than that prevailing in the base period (J=0) and exceeds the base period differential by no more than the upper limit on the retail price adjustment.[1] In that case, the refiner would still be able to simultaneously equate both of his ceiling prices to the corresponding market prices and all results would be preserved.[2]

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1 This relationship between wholesale and retail prices seems to have held throughout the period of the controls. See the footnote on page 146.

2 Chapter VII addresses the consequences of a refiner's being unable to simultaneously equate all of his class-of-purchaser ceiling prices to the relevant market clearing prices.

REVIEW OF POLICY IMPLICATIONS

The results in this chapter imply that the price controls have two adverse effects on gasoline marketing and distribution. First, they serve to increase the cost of marketing any given volume of gasoline. Minimizing the cost of marketing a given volume of gasoline requires that marginal retailing and wholesaling cost be equal across marketers. Given the prevailing prices the constrained refiner will have equilibrium levels of marginal wholesaling and retailing costs which are inefficiently high and will exceed the corresponding marginal costs of unconstrained marketers. In addition, the level of marginal wholesaling and retailing cost will vary across constrained refiners as their equilibrium level will depend on various base period parameters, which are unlikely to be equal across refiners. This is particularly likely, since the level of $Xs^{\circ}$ depends on the proportion of retail and wholesale sales in the base period.

Second, the price controls will have an anticompetitive effect on gasoline marketing and distribution. Constrained refiners will sell gasoline inefficiently far downstream, and the levels of refinery gate sales and wholesale sales are likely to be inefficiently low if not zero. This implies that the sales of independent marketers who purchase their gasoline from constrained refiners will also be inefficiently low unless they buy additional gasoline from unconstrained refiners. These marketers might be able to purchase additional gasoline from unconstrained refiners.

However, the analysis of chapter III, which implicitly concerned the sales of independent marketers who purchase from unconstrained refiners, indicated that such marketers will also have sales that are inefficiently low relative to the sales of integrated marketers.

Although the analysis in this chapter has been developed in terms of sales to customers at various functional levels in the gasoline marketing industry, its relevance is considerably broader. The critical distinction in the model is not between retail sales and wholesale sales but between sales for which the base period margin is positive and relatively high (e.g., $P_m^\circ - P_p^\circ - X_s^\circ$) and those for which the base period margin is negative or low (e.g., $P_w^\circ - P_p^\circ - X_s^\circ$). Since the only differences in the base period margins of different transactions are the base period selling prices, the results can be viewed in terms of transactions with high base period selling prices and those with low base period selling prices. Thus, the analysis above implies an incentive to increase sales associated with high base period prices and reduce sales associated with low base period prices. Such variations in base period selling prices might, as has been assumed, be associated with sales at different functional levels in the gasoline marketing industry; however, such variations may also be due to differences in geographic location of sales as well as simply reflecting some disequilibrium on the base date.

It may seem that the perverse regulatory incentives discusse above could be avoided by making a few changes in the methods determining price differentials and calculating increased marke ing costs. For example, if refiners actually sold gasoline only two economic markets, it would probably have been possib for DOE to set the relationship among the prices in these marke directly and avoid some of the problems discussed above. In pra tice, however, refiners may sell gasoline at a variety of poin in their distribution system as well as at a large number of ge graphic locations, and each of these different types of sale m be associated with a different price. The DOE regulations, there fore, must not only specify a ceiling price for each selling fir but also specify the prices to be accorded a possibly large numb of different types of purchasers and the prices to be accord similar types of purchasers buying product at a large number different locations. Therefore, while the procedure adopted DOE to determine the prices to be charged different customers h been shown to have serious undesirable effects, given the va number of prices to be specified in each period, it is doubtfu whether there is any feasible alternative procedure that would n also induce serious distortions in refiner decisions.

## Chapter VI

## ALLOCATION REGULATIONS AND PASS-THROUGH LIMITS

In this chapter, two aspects of the regulations omitted from the preceding models are examined. These regulatory features are the refined product allocation regulations and the upper limit on the amount of marketing nonproduct costs that may passed through in higher product prices.

In principle, either of these regulatory provisions could severely limit or completely eliminate the regulatory incentive for partially integrated refiners to select inefficiently high levels of downstream sales. The limit on the pass-through of marketing nonproduct costs, hereafter referred to as the marketing cost limit, could in theory also make it unprofitable for firms to select market clearing ceiling prices. The discussion in this chapter suggests, however, that in practice neither of these regulatory provisions is likely to reverse the prediction that partially integrated refiners will be induced to select inefficiently high levels of downstream sales. In addition, most refiners will not be prevented from raising their ceiling prices to the market clearing level by the marketing cost limit.

The reasons for these conclusions can be summarized as follows. Allocation regulations have an effect only when refiners in their absence would be induced to sell at prices below the market clearing level. Further, even when the regulatory allocation mechanism is is effect, it only tends to restore a historic

distribution pattern that may no longer be appropriate. The marketing nonproduct cost limit will prevent excessive downstream sales by integrated refiners only if marketing cost increases occur to an extent judged unlikely. In any event, because of the way increases in marketing nonproduct costs are calculated under the regulations, most refiners should be able to keep the limit from becoming binding by changing the location or functional level at which they purchase gasoline for resale.

THE INTERACTION OF THE PRICE AND ALLOCATION REGULATIONS

The original motivation for the product allocation regulations was presumably to prevent refiners subject to price controls from disproportionately channeling their available gasoline through their own retail outlets. It therefore might be expected that the tendency of the regulations to cause refiners to sell inefficiently far downstream, that was identified in earlier chapters, might be eliminated by the allocation regulations. The discussion below, however, indicates why the allocation regulations cannot be relied upon to prevent regulation-induced distortions of marketing patterns.

The allocation regulations are extremely complex and very likely have their own perverse effects on the behavior of refiners. Their central feature, however, is simply the requirement that if a supplier (in this discussion the supplier is a refiner) sold a certain percentage of his gasoline to a particular customer

in the designated base period,[1] then the supplier must permit that customer to purchase that same percentage of his gasoline in the current period.[2] Note that the regulations require only that the refiner permit the customer to purchase its allocation if the customer so desires. It is not required that the class-of-purchaser price be such that base period customers actually purchase the gasoline that they are offered. Therefore, the actual level of purchases by a base period customer depends not only on the customer's allocation but also on the class-of-purchaser price he must pay.

If the refiner without considering the allocation regulations would select market clearing prices, it can be concluded that the allocation regulations have no effect on the distribution of

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1 The base period for purposes of determining a buyer's allocation fraction is redefined periodically by DOE. This should not be confused with the base period for ceiling price calculations, which remains May 15, 1973.

2 Those familiar with the regulations will note that the allocation requirement is stated differently here than in the regulations. The regulations develop this requirement in terms of base period volumes and current allocation fractions. This is only a difference in the way the requirement is stated, however, for the base period volume of customer i times the ratio of refiner j's current gasoline supply to his base period gasoline supply is identical to the current gasoline supply of refiner j times the ratio of the base period volume of customer i to refiner j's base period gasoline supply.

This study's characterization of the regulations also abstracts from most of their complexities, such as distinctions among customers according to priority of end use, state set-aside provisions, the slightly different provisions regarding the disposition of gasoline in excess of the supplier's base period supply volume (called "surplus"), and provisions for adjustments in base period volume. However, the characterization employed here does capture the allocation regulations' basic nature.

gasoline among the refiner's customers.[1] This follows from the observation that when a firm sells at the market clearing price, all those who wish to buy from that firm are able (by the definition of a market clearing price) to purchase as much as they want at that price, whether or not they have any regulatory allocation right. The models of the preceding chapters have therefore provided illustrations of situations in which refiners would sell too much gasoline downstream despite the allocation regulations. Under the assumptions of those models, the constrained refiner selected a price at the market clearing level without consideration of the allocation regulations. Therefore, it follows that adding the allocation regulations to those models would have had no effect, either qualitative or quantitative, on the conclusions drawn.

It is believed that the analysis of the preceding chapters fairly characterizes many actual situations, and therefore, that the allocation regulations will frequently be irrelevant. There are, however, circumstances in which refiners would choose to set a price below the market clearing level if there were no prospect of base period customers exercising their allocation rights. Conditions under which pricing below the market clearing level may be profitable have been alluded to in earlier chapters and are

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[1] Nor in that case will the allocation regulations have influence on any other aspect of refiner behavior.

discussed in detail in chapter VII.[1] Under these conditions, the allocation regulations are likely to affect the distribution of product and/or the selection of selling prices. This can happen in two ways. First, the prospect of base-period upstream customers exercising their allocation rights if the refiner sets a price below the market clearing level may provide some refiners with an additional incentive to select market clearing upstream prices. Since the price regulations provide even constrained refiners with some pricing flexibility, if the exercise of allocation rights by upstream customers would significantly reduce both downstream sales and refiner profits, these allocation rights may induce refiners to select higher (market clearing) upstream selling prices than they otherwise would.

The allocation regulations will presumably have their greatest effect on the distribution of gasoline in the situation in which refiners find it profit maximizing to select prices below the market clearing level despite the prospect of base period customers exercising their allocation rights. However, even in these cases, for reasons discussed below, the allocation regulations cannot be relied upon to prevent an inefficiently high level of downstream sales by constrained refiners.

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[1] It should be pointed out that the analysis of chapter VII suggests that instances of pricing below the market clearing price are likely to be transitory and/or restricted to a limited number of sellers in a limited number of markets.

If a refiner sells at a price below the market clearing level, his base period customers have a strong incentive to exercise their allocation rights, and when product is distributed in accordance with the regulatory allocation fractions, it is quite probable that the refiner will be forced to sell more product upstream than the models of earlier chapters would imply. There is no reason to believe, however, that the allocation fractions provide for the efficient distribution of gasoline among functional levels, and they may understate the fraction of product that would be sold to independent firms in the absence of price regulation. Since the allocation fractions are based on past conditions, that are likely to be an inappropriate guide to efficiency in any current period. The allocation regulations have apparently caused serious misdirection of gasoline during past periods of supply reduction because they failed to reflect major changes in market conditions that had occurred since the May 1973 base period date. DOE now periodically redefines the base period for allocation in an apparent attempt to mitigate this problem. However, changes in the base period still lag behind market changes. In addition, to the extent that base periods are now periods in which the regulations were in effect, the inefficiently high levels of downstream sales that were shown in previous chapters to characterize regulated equilibria will be embodied in the allocation fractions.

Thus, the results of the previous chapters are qualitatively valid even when the effects of the allocation regulations are recognized. If the assumptions of the preceding models are valid, the previous results are completely unaffected by the allocation regulations, because market clearing prices are profit maximizing for the refiner and allocation rights will not affect the quantity purchased by any buyers. This will be a normal situation, it appears, even when the regulations are binding. If a refiner, in the absence of allocation regulations, would be induced to price below the market clearing level, the allocation regulations may force that refiner to sell more of his gasoline upstream than the model of the earlier chapters would imply. However, the refiner's allocation of gasoline among distribution channels is still likely to be inefficient, both because the allocation fractions are based on past conditions and because product flows in the base period (for allocation) will reflect the regulatory distortions identified in previous chapters.

THE LIMIT ON THE PASS-THROUGH OF MARKETING NONPRODUCT COSTS

The models employed in the previous chapters have not taken account of a regulatory limit on the amount of increased marketing nonproduct costs that may be passed through by sellers. The total increased marketing nonproduct costs that may be recouped through higher product prices is limited to 3 cents per gallon of retail

sales plus .75 cents per gallon on nonretail sales.[1] This provision is potentially significant because it could qualitatively alter some of the results generated in previous chapters. It could, in theory, eliminate the incentive of constrained refiners to select an inefficiently high absolute volume of retail sales, to select an inefficiently high level of retail sales relative to wholesale sales, and to charge market clearing prices. However, the discussion below suggests that in practice it is unlikely that this provision has had or will have any of these effects.

One reason that the marketing cost limit has probably not eliminated the regulatory incentives for integrated refiners to sell inefficiently far downstream is that nonproduct marketing costs have not increased sufficiently since the base period. It can be shown that even if the marketing cost limit is binding, the integrated refiner will still retail more than he would in absence of controls if

[6-1] $\bar{P}m - Pp < Pm^{\circ} - Pp^{\circ} + 3$,

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[1] Thus, in the notation of the previous chapters, all of the increased marketing nonproduct costs may be passed through only if $Xs - Xs^{\circ} < (3Vm + .75Vw)/Vs$, where all values are in cents and gallons.

In spite of the way in which this limit is computed, this provision has nothing to do with the manner in which increased marketing costs are allocated between retail and nonretail class of purchaser ceiling prices, nor does this provision provide separate limits for increased retail and nonretail marketing nonproduct costs. It merely places a limit on the aggregate marketing costs which may be passed through in higher prices. The only provision of the regulations permitting differential cost passthrough for different sales is the retail price adjustment exception to the equal application rule, which was described above.

where all values are in cents per gallon.[1] He will select an inefficiently high level of retail sales relative to wholesale sales if

[6-2] $\bar{P}m - \bar{P}w < Pm^{\circ} - Pw^{\circ} + 2.25$,

again, in cents per gallon. Note that each of these conditions will hold unless the equilibrium price spreads have increased more than a certain number of cents since the base period.

If these conditions are satisfied, adding the marketing cost limitation to the models previously developed will not qualitatively change the earlier conclusions about the regulations' tendency to induce inefficient and anticompetitive behavior by integrated firms. The predicted size of the effects may be reduced when the limit is considered; but so long as [6-1]-[6-2] hold, the effects will still exist.

Although the evidence is admittedly weak, it is believed that conditions [6-1]-[6-2] have generally held during the regulatory period to date.[2] While it might be expected that the general cost

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1 The derivation of conditions [6-1] and [6-2] is in the appendix to this chapter. The conditions are sufficient but not necessary to generate the marketing inefficiencies previously identified.

2 Since conditions [6-1]-[6-2] involve only simple average values, empirical evaluation is easy in principle. In practice, however, the necessary company-specific data are not publicly available. Aggregate data that are available, however, suggest that the conditions have usually been satisfied. For example, it is known that the average value of the dealer margin in May 1973 ($Pm^{\circ} - Pw^{\circ}$) was about 7.28 cents per gallon. (See Charles R. Owens, "History of Petroleum Price Controls," appendix D, p. 1331, in Historical Working Paper on the Economic Stabilization Program,

(footnote continues on next page)

inflation since May 15, 1973 would have raised equilibrium marketing margins to a degree that would invalidate these conditions, this tendency for equilibrium margins to rise has been partly offset by two other developments. First, in response to the sharp increase in gasoline prices there has been a decrease in the quantity of gasoline demanded relative to the demand projected in the base period. This has contributed to a surplus of gasoline

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(footnote continued)
August 15, 1971 to April 30, 1974, part II.) Thus, for the average unintegrated marketer,

$$Pm^{\circ} - Pw^{\circ} + 2.25 = 9.53 \text{ cents per gallon.}$$

Average values of $\overline{Pm} - Pw$ have tended to be less than 9.53 cents per gallon, indicating that condition [6-1] has generally been satisfied. The average value of $\overline{Pm} - Pw$ for dealers has varied over time as follows.

| Year | Margin (¢/gallon) |
|---|---|
| 1974 | 9.7 |
| 1975 | 8.4 |
| 1976 | 7.6 |
| 1977 | 8.3 |
| 1978 | 8.6 |

See U.S. Department of Energy, Draft Environmental Impact Statement Motor Gasoline Deregulation, pp. IV-10, November 1978.

Since the DOE regulations have generally not constrained the pricing of unintegrated marketers because of the differential regulations applying to these marketers (discussed in footnote 2, p. 115 of chapter V), the actual margins of these marketers can be interpreted as placing an upper bound on $\overline{Pm} - \overline{Pw}$. It is an upper bound because some such marketers may have purchased gasoline at sub-market prices (i.e., $Pw < \overline{Pw}$), thereby inflating their actual margin. Situations in which the regulations may cause $Pw < \overline{Pw}$ are discussed in chapter VII.

marketing capacity. Second, the retail market in the base period was characterized by a large number of low-volume service stations. Since that time there has been a trend toward much higher-volume stations, which are better able to realize economies of scale in retailing.

It was noted at the outset of this chapter, and it is shown in the appendix, that the marketing cost limit, if binding, could make it unprofitable for a seller to generate market clearing ceiling prices. This is possible whether or not conditions [6-1] and [6-2] are satisfied. Empirically, however, the apparent absence of any criticism of the adequacy of the marketing cost limit by constrained refiner-marketers suggests that this limit has, at least historically, not prevented the selection of market clearing prices. Moreover, there is reason to believe that the conclusions of the previous chapters concerning market clearance will remain generally valid for integrated marketers in the future despite the marketing cost limit. As shown below, a typical integrated marketer can easily relax the marketing cost constraint by purchasing product farther downstream. The ease with which this constraint can be relaxed also suggests that inefficient levels of downstream sales by integrated marketers will not be prevented by the marketing cost limit even if conditions [6-1] and [6-2] should fail to be satisfied in the future.

The way in which the marketing cost limit can be relaxed is most easily shown with an example. Consider a refiner who purchases gasoline in Houston, transports this gasoline from Houston via pipeline to the Atlanta pipeline terminal, transfers the gasoline into trucks at the pipeline terminal, and delivers the gasoline to his Atlanta retail outlets, which then sell the gasoline to consumers. All of the costs incurred by the refiner between the time the gasoline is purchased in Houston and the time it is eventually sold at retail are marketing nonproduct costs (to the extent that the costs are allowable). If this refiner's marketing nonproduct costs rose to the point that the marketing cost limit prevented all such costs from being passed through in the selling price, the refiner could relax the marketing cost limit by purchasing gasoline at the Atlanta pipeline terminal instead of in Houston. This action would essentially turn the costs incurred in transporting the gasoline to Atlanta (the pipeline tariff) from marketing nonproduct costs into purchased product costs, on which there are no limits on cost increases. The refiner's total increased marketing nonproduct costs would be reduced by the amount of the pipeline tariff, permitting the refiner to pass through in product prices a like amount of other marketing nonproduct costs.

This ability of an integrated firm to relax the pass-through constraint derives from the way in which the increased cost of purchased product is calculated when gasoline is purchased in more than one market. The regulations require that the increased cost of purchased gasoline be calculated by multiplying the current total volume of all purchases of gasoline by the difference between the current and base period weighted average cost of purchased gasoline. The distortions created by this procedure are closely analogous to those created by the method of calculating increased marketing costs. Thus, while the average cost of purchased product will rise if the cost of purchasing product at a specific location (or functional level) rises, which is appropriate, it will also rise if product is purchased farther downstream.[1] This method of calculating product costs preserves the incentive to sell gasoline inefficiently far downstream as a refiner is still able to essentially recover some distribution costs twice--once when he recovers the cost of purchasing the product downstream instead of upstream, and again when he resells the product downstream and recoups the base period margin on such downstream sales.

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[1] If the base period cost of product were defined separately for each market (e.g., refinery gate, dealer tank wagon, at New York, at Houston, at Atlanta, etc.) the ability of refiners to change marketing costs into product costs in this fashion would disappear. However, there are numerous markets, and market definition is often judgmental. The administrative costs of a rule complicated in this way would be greatly increased.

The magnitude of the potential relaxation in the limit on the marketing cost pass-through obtainable through downstream gasoline purchases may be seen by comparing condition [6-1] with the corresponding condition if the firm is able to purchase gasoline downstream. These conditions are:

[6-1] $\bar{P}m - Pp < Pm^\circ - Pp^\circ + 3$, and

[6-3] $\bar{P}m - Ppw < Pm^\circ - Ppp^\circ + 3$,

where all values are in cents per gallon, $Ppp^\circ$ is the weighted average cost of purchased gasoline in the base period (including both refinery gate and downstream purchases), and Ppw is the current price of gasoline purchased downstream. If the refiner had few downstream gasoline purchases in the base period, $Ppp^\circ$ will be close to the refinery gate price in the base period and condition [6-3] will be much looser than condition [6-1].

Condition [6-3] is particularly striking because if Ppw is for instance, the wholesale price and $Ppp^\circ$, the base period refinery gate price, then the condition will be satisfied until the current retail margin ($\bar{P}m - Ppw$) rises more than 3 cents above not just the base period retail margin ($Pm^\circ - Pw^\circ$) but more than 3 cents above the entire base period margin on gasoline purchased at the refinery gate and sold retail. Condition [6-3] is therefore likely to continue to be satisfied for many refiners unless a substantial cost inflation continuing over a considerable number of years causes a very large increase in the equilibrium marketing margins.

This may be illustrated by again considering the hypothetical supply of gasoline to Atlanta described above. Suppose that Pm is the retail price in Atlanta, Ppw the price at the Atlanta pipeline terminal, and Pp the refinery gate price in Houston. Then unless the current margin between the Atlanta terminal and retail prices rises to more than 3 cents above the difference between the Houston price and the Atlanta retail price in the base period, the refiner will be induced to select an inefficiently high level of retail sales. In fact, if the refiner purchases gasoline at the Atlanta pipeline terminal, increased retail sales of purchased gasoline will be profitable until the marginal cost of moving this gasoline from the terminal and retailing it exceeds the base period difference between the Atlanta retail price and the Houston refinery gate price by more than 3 cents per gallon.

The possibilities for geographically altering downstream purchases of gasoline strongly suggest that the limit on the pass-through of marketing costs is unlikely to deter constrained refiners from selecting an inefficiently high level of downstream sales. Nor, for the same reason, is it likely to cause refiners to find it unprofitable to equate their ceiling price to the market price. The limit on the marketing nonproduct cost pass-through is therefore not expected to qualitatively alter the predictions of the preceding models.

## APPENDIX TO CHAPTER VI

It was stated above that the results that the controls will induce the constrained refiner to select an inefficiently high level of retail sales both in absolute terms and relative to the level of wholesale sales are unaffected by the limit on the pass-through of increased marketing nonproduct costs if the following sufficient conditions are satisfied:

$$[6\text{-}4] \qquad \bar{P}m - \bar{P}w < Pm^{\circ} - Pw^{\circ} + 2.25$$

$$[6\text{-}5] \qquad \bar{P}m - Pp < Pm^{\circ} - Pp^{\circ} + 3,$$

where all values are in cents per gallon. This statement is proven below.

### THE MODEL

The model employed in analyzing the effects of the limit on the pass-through of marketing nonproduct costs is closely related to that employed in chapter V. Refiner profits are written

$$[6\text{-}6] \qquad \Pi = VmPm + VwPw + (1-G)VrPu - Ar - Nr - Rr - Aw - Nw - Rw - Am - Nm - Rm - VpPp.$$

In maximizing profits, the refiner is constrained to select his selling prices Pm, and Pw, such that

$$[6\text{-}7] \qquad Pm \leq Zm = Pm^{\circ} + Y + J - J(Vm/Vs)$$

and

$$[6\text{-}8] \qquad Pw \leq Zw = Pw^{\circ} + Y - J(Vm/Vs),$$

where Y is defined as

$$[6\text{-}9] \qquad Y = \frac{GVr}{(GVr + Vp)} (Xr - Xr^{\circ}) + \frac{Vp\ (Pp - Pp^{\circ})}{(GVr + Vp)} + Xs - Xs^{\circ}.$$

The limit on the marketing nonproduct cost pass-through is incorporated in the model by requiring that the selling prices selected by the refiner not only satisfy equations [6-7]-[6-8] above, but also satisfy

$$[6\text{-}10] \qquad Pm \leq \hat{Zm} = Pm^{\circ} + \hat{Y} + J - J(Vm/Vs)$$

$$[6\text{-}11] \qquad Pw \leq \hat{Zw} = Pw^{\circ} + \hat{Y} - J(Vm/Vs),$$

where $\hat{Y}$ is defined as follows:

$$[6\text{-}12] \qquad \hat{Y} = \frac{GVr(Xr - Xr^{\circ})}{(GVr + Vp)} + \frac{Vp(Pp - Pp^{\circ})}{(GVr + Vp)} + \frac{(3Vm + .75Vw)}{Vs},$$

and all values are in cents per gallon.

As in the previous models, it is assumed that there are no inventories and therefore that

$$[6\text{-}13] \qquad GVr + Vp - Vm - Vw = 0.$$

The relevant Lagrangian for this refiner is therefore

$$[6\text{-}14] \qquad L = \pi + \lambda_1 (Zm - Pm) + \lambda_2(\hat{Zm} - Pm) + \lambda_3(\overline{Pm} - Pm) + \lambda_4(Zw - Pw)$$
$$+ \lambda_5(\hat{Zw} - Pw) + \lambda_6(\overline{Pw} - Pw) + \lambda_7(GVr + Vp - Vm - Vw).$$

The analysis of the refiner's profit-maximization decision is again strictly short-run (the refiner's capital stock and gasoline fraction are assumed to be fixed and the same as in the absence of controls), and the refiner's choice variables are therefore Vr, Vp, Vm, Vw, Pm, Pw, and J. If the equilibrium values of these choice variables are all greater than zero, the necessary conditions for profit maximization are

$$[6\text{-}15]\quad \frac{\partial L}{\partial Vm} = Pm - \partial Aw/\partial Vm - \partial Am/\partial Vm + \lambda_1(\partial Zm/\partial Vm) + \lambda_2(\partial \hat{Z}m/\partial Vm) + \lambda_4(\partial Zw/\partial Vm) + \lambda_5(\partial \hat{Z}w/\partial Vm) - \lambda_7 = 0$$

$$[6\text{-}16]\quad \frac{\partial L}{\partial Vw} = Pw - \partial Aw/Vw + \lambda_1(\partial Zm/\partial Vw) + \lambda_2(\partial \hat{Z}m/\partial Vw) + \lambda_4(\partial Zw/\partial Vw) + \lambda_5(\partial \hat{Z}w/\partial Vw) - \lambda_7 = 0$$

$$[6\text{-}17]\quad \frac{\partial L}{\partial Vp} = -Pp + \lambda_1(\partial Zm/\partial Vp) + \lambda_2(\partial \hat{Z}m/\partial Vp) + \lambda_4(\partial Zw/\partial Vp) + \lambda_5(\partial \hat{Z}w/\partial Vw) + \lambda_7 = 0$$

$$[6\text{-}18]\quad \frac{\partial L}{\partial Pm} = Vm - \lambda_1 - \lambda_2 - \lambda_3 = 0$$

$$[6\text{-}19]\quad \frac{\partial L}{\partial Pw} = Vw - \lambda_4 - \lambda_5 - \lambda_6 = 0$$

$$[6\text{-}20]\quad \frac{\partial L}{\partial J} = \lambda_1(\partial Zm/\partial J) + \lambda_2(\partial \hat{Z}m/\partial J) + \lambda_4(\partial Zw/\partial J) + \lambda_5(\partial \hat{Z}w/\partial J) = 0$$

$$[6\text{-}21]\quad \lambda_1\left(\frac{\partial L}{\partial \lambda_1}\right) = \lambda_1(Zm - Pm) = 0$$

$$[6\text{-}22]\quad \lambda_2\left(\frac{\partial L}{\partial \lambda_2}\right) = \lambda_2(\hat{Z}m - Pm) = 0$$

[6-23] $\lambda_3(\frac{\partial L}{\partial \lambda_3}) = \lambda_3(\bar{P}m - Pm) = 0$

[6-24] $\lambda_4(\frac{\partial L}{\partial \lambda_4}) = \lambda_4(\hat{Z}w - Pw) = 0$

[6-25] $\lambda_5(\frac{\partial L}{\partial \lambda_5}) = \lambda_5(\hat{Z}w - Pw) = 0$

[6-26] $\lambda_6(\frac{\partial L}{\partial \lambda_6}) = \lambda_6(\bar{P}w - Pw) = 0$

[6-27] $\frac{\partial L}{\partial \lambda_7} = GVr + Vp - Vm - Vw = 0.$

EQUILIBRIA AND MARKET CLEARANCE

First order conditions [6-15] -[6-27] describe seven distinct potential equilibria depending on the solution values of the multipliers. It is shown below that in those equilibria in which the limit on the pass-through of marketing non-product costs is binding ($\lambda_2>0, \lambda_5>0$), conditions [6-4] and [6-5] above are sufficient conditions for the controls to induce constrained refiners to select an inefficiently high level of retail sales in absolute and relative terms.

It is convenient to categorize the potential equilibria as follows:

Type A: $\lambda_1 = \lambda_2 = 0$

Type B: $\lambda_2 = \lambda_3 = 0, \lambda_1 > 0$

Type C: $\lambda_2 = 0, \lambda_1 > 0, \lambda_3 > 0$

Type D: $\lambda_1 = \lambda_3 = 0, \lambda_2 > 0$

Type E: $\lambda_1 = 0, \lambda_2 > 0, \lambda_3 > 0$

Type F: $\lambda_3 = 0, \lambda_1 > 0, \lambda_2 > 0$

Type G: $\lambda_1 > 0, \lambda_3 > 0, \lambda_2 > 0.$

Three of these potential equilibria (types A, B, and C above) are characterized by $\lambda_2=0$, implying that the limit on the pass-through of marketing non-product costs is not binding. These equilibria are not considered below, as they are essentially the same as those analyzed in chapter V. The last four of these potential equilibria are considered below in sequence.

Type D: $\lambda_1 = 0$, $\lambda_2>0$, $\lambda_3 = 0$

In this type of equilibrium the refiner finds it unprofitable to equate either his retail or wholesale ceiling prices to the corresponding market prices and the limit on the marketing cost pass-through is binding. This may be seen by observing that $\lambda_2>0$ implies $Pm=\hat{Z}m$, which implies that the limit on the marketing cost pass-through is binding. On the other hand, $\lambda_3=0$ implies that $Pm<\overline{P}m$ and thus that the refiner finds it unprofitable to equate his retail ceiling price to the market price.[1]

To show that the refiner's wholesale prices are similarly constrained, it is observed that equation [6-12] simplifies to[2]

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[1] The latter observation is, as noted in chapter V, not strictly correct, as it could be the case that the market price constraint is exactly satisfied ($\overline{P}m=Pm$) but nonbinding ($\lambda_3=0$). The possibility that constraints may be satisified but nonbinding is ignored throughout this appendix, as explicit consideration of this possibility would substantially complicate the exposition but have no effect on the results. This may be readily verified by the interested reader.

[2] Equation [6-28] is obtained by calculating the partial derivatives of $\hat{Z}$ and $Z$ in equation [6-20].

[6-28] $(\lambda_1 + \lambda_2)(Vw/Vs) - (\lambda_4 + \lambda_5)(Vm/Vs) = 0.$

Since $\lambda_2$ is greater than zero, equation [6-28] is satisfied for nonzero levels of Vw only if $\lambda_4+\lambda_5$ is greater than zero. Since by the definition of $\hat{Z}$ and Z, $\hat{Z}m<Zm$ implies $\hat{Z}w<Zw$, $\lambda_4=0$ and $\lambda_5>0$. Similarly, $\lambda_3=0$ implies that $\lambda_6=0$ and thus that $Pw<\bar{P}w$. This may be seen by employing equations [6-18] and [6-19] to rewrite equation [6-28] as

[6-29] $\lambda_6(Vm/Vs) - \lambda_3(Vw/Vs) = 0.$

If $\lambda_3=0$, this equation is satisfied for $Vm>0$ only if $\lambda_6=0$ and $Pw<\bar{P}w$.

To show that the refiner in this type of equilibrium will select an inefficiently high level of retail sales in both absolute and relative terms if conditions [6-4] and [6-5] are satisfied, equations [6-15] and [6-16] are reduced to[1]

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1 Equations [6-30] and [6-31] are obtained by employing equation [6-17] to substitute for $\lambda_7$ in equations [6-15] and [6-16]. $\lambda_1$, $\lambda_3$, $\lambda_4$ and $\lambda_6$ are then set equal to zero and it is observed that equations [6-18] and [6-19] then require that $\lambda_2=Vm$ and that $\lambda_5=Vw$. This yields:

$$\frac{\partial L}{\partial Vm} = Pm - \partial Am/\partial Vm - \partial Aw/\partial Vm - Pp + Vm(\partial \hat{Z}m/\partial Vm + \partial \hat{Z}m/\partial Vp) + Vw(\partial \hat{Z}w/\partial Vm + \partial \hat{Z}m/\partial Vp) = 0$$

$$\frac{\partial L}{\partial Vw} = Pw - \partial Aw/\partial Vm - Pp + Vm(\partial \hat{Z}m/\partial Vw + \partial \hat{Z}m/\partial Vp) + Vw(\partial \hat{Z}w/\partial Vw + \partial \hat{Z}w/\partial Vp) = 0.$$

The partial derivatives of $\hat{Z}$ are then evaluated and the resulting expressions simplified. In simplifying these expressions, it is helpful to note that

(footnote continues on next page)

[6-30] $Pm^{\circ} - Pp^{\circ} + 3 - \partial Am/\partial Vm - \partial Aw/\partial Vw = 0$

[6-31] $Pw^{\circ} - Pp^{\circ} + .75 - \partial Aw/\partial Vw = 0,$

which in turn imply that

[6-32] $Pm^{\circ} - Pw^{\circ} - \partial Am/\partial Vm + 2.25 = 0.$

Equation [6-30] and condition [6-5] require that in equilibrium,

[6-33] $\overline{Pm} < \partial Am/\partial Vm + \partial Aw/\partial Vm + Pp.$

This implies that the level of retail sales is inefficiently high in absolute terms, since marginal cost exceeds the retail price.

Similarly, equation [6-32] and condition [6-4] require that

[6-34] $\overline{Pm} - \overline{Pw} < \partial Am/\partial Vm.$

This implies that the level of retail sales is inefficiently high relative to the level of wholesale sales, since the incremental cost of selling retail instead of wholesale exceeds the incremental revenue.

Type E: $\lambda_1=0, \lambda_2>0, \lambda_3>0$

This equilibrium differs from that considered above in that the refiner finds it profitable to equate each of his ceiling

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(footnote continued)

$\hat{\partial Zm}/\partial Vm = \hat{\partial Zw}/\partial Vm$ and that:

$$\hat{\partial Zm}/\partial Vm + \hat{\partial Zm}/\partial Vp = \frac{1}{Vs} ( -J + J(Vm/Vs) + Pp - Pp^{\circ} + 3 - \hat{Y})$$

can also be written:

$$\hat{\partial Zm}/\partial Vm + \hat{\partial Zm}/\partial Vp = \frac{1}{Vs} ( -\hat{Zm} + Pm^{\circ} + Pp - Pp^{\circ} + 3).$$

prices to the corresponding market prices. This is shown by observing that $\lambda_2>0$ implies that $Pm=\hat{Z}m$ and that $\lambda_3>0$ implies $\bar{P}m=Pm$. Thus, the refiner is constrained by the regulations but sets a retail price equal to the retail market price. To show that the refiner's wholesale prices are similarly constrained, it is observed that equation [6-28] requires that if $\lambda_2>0$ for positive levels of Vw, then $\lambda_4+\lambda_5$ must also be positive. Then, since $\hat{Z}m<Zm$ implies $\hat{Z}w<Zw$, $\lambda_4=0$ and $\lambda_5>0$. Similarly, if $\lambda_3>0$, equation [6-29] is satisified for positive levels of Vw only if $\lambda_6$ is also positive. Thus, $\lambda_6>0$ and $Pw=\bar{P}w$.

As in the previous equilibrium, it is shown that the constrained refiner is induced by the controls to select an inefficiently high level of retail sales in both absolute and relative terms. These results are obtained by first simplifying equations [6-15] and [6-16] by letting $\lambda_1$ and $\lambda_4$ equal zero and solving out $\lambda_7$, which yields the following first order conditions:

$$[6\text{-}35]\quad \frac{\partial L}{\partial Vm} = Pm - Pp - \partial Am/\partial Vm - \partial Aw/\partial Vw + \lambda_2(\partial \hat{Z}m/\partial Vm + \partial \hat{Z}m/\partial Vp) + \lambda_5(\partial \hat{Z}w/\partial Vm + \partial \hat{Z}w/\partial Vp) = 0$$

$$[6\text{-}36]\quad \frac{\partial L}{\partial Vw} = Pw - Pp - \partial Aw/\partial Vw + \lambda_2(\partial \hat{Z}m/\partial Vw + \partial \hat{Z}m/\partial Vp) + \lambda_5(\partial \hat{Z}w/\partial Vw + \partial \hat{Z}w/\partial Vp) = 0.$$

To show that the absolute level of retail sales is inefficiently high, it is observed that if

[6-37] $\lambda_2(\partial\hat{Z}m/\partial Vm + \partial\hat{Z}m/\partial Vp) + \lambda_5(\partial\hat{Z}w/\partial Vm + \partial\hat{Z}w/\partial Vp) > 0,$

then

[6-38] $Pm - Pp - \partial Am/\partial Vm - \partial Aw/\partial Vw < 0.$

Since $Pm=\overline{P}m$, this implies that the marginal cost of retail sales exceeds the retail market price.

To show that [6-37] is positive, the partials of $\hat{Z}$ are evaluated and [6-37] is rewritten as

[6-39] $(\lambda_2 + \lambda_5)(-\hat{Z}m + Pm^\circ + 3 + Pp - Pp^\circ).$

Since $\lambda_2$ and $\lambda_5$ are both positive and $Zm=\overline{P}m$, equation [6-39] must be positive in equilibrium if condition [6-5] is valid.

The result that the level of retail sales is inefficiently high relative to the level of wholesale sales is obtained by subtracting equation [6-36] from equation [6-35], evaluating the partial derivatives of $\hat{Z}$, and setting Pm equal to $\overline{P}m$ and Pw equal to $\overline{P}w$, which yields

[6-40] $\overline{P}m - \overline{P}w - \partial Am/\partial Vm + (\lambda_2 + \lambda_5)(2.25 - J) = 0.$

If 2.25-J is positive, then since $\lambda_2$ and $\lambda_5$ are positive,

[6-41] $\overline{P}m - \overline{P}w - \partial Am/\partial Vm < 0,$

which implies that the incremental cost of selling retail instead of wholesale exceeds the incremental revenue. To show that 2.25-J is positive in equilibrium, it is noted that the definitions of $\hat{Z}w$ and $\hat{Z}m$ (equations [6-10] and [6-11]) require that

[6-42] $J = \hat{Z}m - \hat{Z}w - Pm^\circ + Pw^\circ.$

Since $\hat{Z}m = \overline{P}m$ and $\hat{Z}w = \overline{P}w$, 2.25-J is equal to

[6-43] $Pm^{\circ} - Pw^{\circ} + 2.25 - \bar{P}m + \bar{P}w$.

This expression must be positive if condition [6-4] is valid.

Type F: $\lambda_1>0$, $\lambda_2>0$, $\lambda_3 = 0$

This type of equilibrium is characterized by the exact equality of $Z$ and $\hat{Z}$, which are both less than the corresponding market prices. This may be seen by noting that $\lambda_1$ and $\lambda_2$ greater than zero implies that

[6-44] $Zm = \hat{Z}m = Pm$,

while $\lambda_3 = 0$ implies that $\bar{P}m<Pm$. To show that the refiner's wholesale prices are similarly constrained, it is observed that by equation [6-28], $\lambda_1+\lambda_2>0$ implies that $\lambda_4+\lambda_5$ must also be positive for nonzero levels of wholesale sales. Since $\hat{Z}m=Zm$ implies $\hat{Z}w = Zw$, $\lambda_4$ and $\lambda_5$ are both positive. Equation [6-29] is then employed to show that if $Vm$ is greater than zero and $\lambda_3$ is equal to zero, then $\lambda_6$ must also be equal to zero, and thus $Pw<\bar{P}w$. As an aside, it should be recognized that the exact equality of $\hat{Z}$ and $Z$ in equilibrium is not nearly is coincidental as it might seem, as this equality simply implies that once the limit on the marketing cost pass-through becomes effective, further sales are unprofitable.

The result that the controls induce the constrained refiner to select a level of retail sales which is inefficiently high in both absolute and relative terms is obtained by simplifying first order conditions [6-15] and [6-16] to

[6-45] $\frac{\partial L}{\partial Vm} = Pm - Pp - \partial Am/\partial Vm - \partial Aw/\partial Vm = \lambda_1(\partial Zm/\partial Vm + \partial Zm/\partial Vp) + \lambda_2(\partial\hat{Z}m/\partial Vm + \partial\hat{Z}m/\partial Vp) + \lambda_4(\partial Zw/\partial Vm + \partial Zw/\partial Vp) + \lambda_5(\partial\hat{Z}w/\partial Vm + \partial\hat{Z}w/\partial Vp) = 0$

[6-46] $\frac{\partial L}{\partial Vw} = Pw - Pp - \partial Aw/\partial Vw + \lambda_1(\partial Zm/\partial Vw + \partial Zm/\partial Vp) + \lambda_2(\partial\hat{Z}m/\partial Vw + \partial\hat{Z}m/\partial Vp) + \lambda_4(\partial Zw/\partial Vw + \partial Zw/\partial Vp) + \lambda_5(\partial\hat{Z}w/\partial Vw + \partial\hat{Z}w/\partial Vp) = 0.$

The effect of the controls on the absolute level of retail sales is obtained by observing that since $\lambda_2 = Vm - \lambda_1$,[1] $\lambda_5 = Vw - \lambda_4$[2] and $\partial\hat{Z}m/\partial Vm + \partial\hat{Z}m/\partial Vp = \partial\hat{Z}w/\partial Vm + \partial\hat{Z}w/\partial Vp$,[3] equation [6-45] may be rewritten as[4]

[6-47] $\bar{P}m - Pp - \partial Am/\partial Vm - \partial Aw/\partial Vm + (Pm^\circ - Pp^\circ + 3 - \bar{P}m + Pp) + \lambda_1(\partial Zm/\partial Vm + \partial Zm/\partial Vp - \partial\hat{Z}m/\partial Vm - \partial\hat{Z}m/\partial Vp) = 0.$

Since $(Pm^\circ - Pp^\circ + 3 - \bar{P}m + Pp)$ must be positive if condition [6-5] is satisfied, if

[6-48] $\partial Zm/\partial Vm + \partial Zm/\partial Vp - \partial\hat{Z}m/\partial Vm - \partial\hat{Z}m/\partial Vp > 0,$

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1 By equation [6-18].

2 By equation [6-19].

3 As noted previously.

4 Equation [6-47] is obtained from [6-45] by employing the substitutions above, noting that $(Vw+Vm)(\partial\hat{Z}m/\partial Vm + \partial\hat{Z}m/\partial Vp) = -\hat{Z}m + Pm^\circ + Pp - Pp^\circ + 3$, adding $\bar{P}m - \bar{P}m$ and noting that $\hat{Z}m = Pm$.

then

[6-49] $Pm - Pp - \partial Am/\partial Vm - \partial Aw/\partial Vm < 0,$

which implies that marginal cost exceeds the retail price.

Expression [6-48] is shown to be positive by substituting $\lambda_1 = Vm - \lambda_2$ and $\lambda_4 = Vw - \lambda_5$ into equation [6-45]. The resulting expression can be simplified to

[6-50] $Pm^\circ - Pp^\circ - Xs^\circ + (\lambda_2+\lambda_5)(\partial\hat{Z}m/\partial Vm + \partial\hat{Z}m/\partial Vp - \partial Zm/\partial Vm - \partial Zm/\partial Vp) = 0.$

Since $Pm^\circ - Pp^\circ - Xs^\circ$ is assumed to be positive, the remaining term in equation [6-50] must be negative. Since this term is the negative of expression [6-48], the latter must be positive. Thus, the regulations induce the constrained refiner to select an inefficiently high level of retail sales in absolute terms in this equilibrium.

The result that the level of retail sales is inefficiently high relative to the level of wholesale sales is obtained by subtracting equation [6-46] from equation [6-45] and evaluating the partial derivatives of $Z$ and $\hat{Z}$, which yields

[6-51] $$Pm - Pw - \partial Am/\partial Vm + \frac{(\lambda_1+\lambda_4)}{Vs}(Pm^\circ - Pw^\circ - Zm + Zw + \partial Am/\partial Vm) + \frac{1}{Vs}(\lambda_2+\lambda_5)(Pm^\circ - Pw^\circ - \hat{Z}m + \hat{Z}w + 2.25) = 0.$$

By substituting $Vs - \lambda_1 - \lambda_4$ for $\lambda_2+\lambda_5$, this expression can be further simplified to[1]

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1 In achieving this simplification, one notes that $Pm=Zm$, $Pw=Zw$, $\hat{Z}w=\hat{Z}w$, $\hat{Z}m=\hat{Z}m$. $\bar{P}m-\bar{P}m + \bar{P}w-\bar{P}w$ is then added.

[6-52] $\bar{P}m - \bar{P}w - \partial Am/\partial Vm + (Pm^{\circ} - Pw^{\circ} + 2.25 - \bar{P}m + \bar{P}w) + \frac{(\lambda_1+\lambda_4)}{Vs}(\partial Am/\partial Vm - 2.25) = 0.$

Since $(Pm^{\circ}-Pw^{\circ} + 2.25 - \bar{P}m + \bar{P}w)$ must be positive if condition [6-4] is valid, if $\partial Am/\partial Vm - 2.25$ is positive, then

[6-53] $\bar{P}m - \bar{P}w - \partial Am/\partial Vm < 0,$

which implies that in equilibrium the incremental cost of selling gasoline retail instead of wholesale is greater than the incremental revenue.

To show that $\partial Am/\partial Vm - 2.25$ must be positive in this equilibrium, $Vs-\lambda_2-\lambda_5$ is substituted for $\lambda_1+\lambda_4$ in equation [6-51]. This yields

[6-54] $Pm^{\circ} - Pw^{\circ} + \frac{(\lambda_2+\lambda_5)}{Vs}(2.25 - \partial Am/\partial Vm) = 0.$

Since $Pm^{\circ}-Pw^{\circ}$ is assumed to be positive, $2.25-\partial Am/\partial Vm$ must be negative. Thus, the controls induce the refiner in this type of equilibrium to select an inefficiently high level of retail sales relative to the level of wholesale sales.

Type G: $\lambda_1>0, \lambda_2>0, \lambda_3>0$

In this type of equilibrium the refiner finds it profitable to equate his ceiling prices to the market prices, and the limit on the pass-through of market costs is reached but not exceeded. Since $\lambda_1, \lambda_2$ and $\lambda_3$ are all positive, $Pm=\hat{Z}m=Zm=\bar{P}m$ and the

refiner's retail ceiling price equals the retail market price. To show that the same characterization applies to wholesale prices, it is noted that equation [6-28] requires that since $\lambda_1+\lambda_2$ is positive, $\lambda_4+\lambda_5$ must also be positive for nonzero levels of Vw. Since $\hat{Z}m=Zm$ implies that $\hat{Z}w=Zw$, $Pw=Zw=\hat{Z}w$ and $\lambda_4$ and $\lambda_5$ are each positive. To show that the wholesale ceiling price is equal to the wholesale market price, it is observed that equation [6-29] requires that if Vw and $\lambda_3$ are both positive, than $\lambda_6$ must also be positive. Thus, $Pw=\hat{Z}w=Zw=\bar{P}w$.

In the discussion below, its is shown once again that the controls will induce constrained refiners to select an inefficiently high level of retail sales in both absolute and relative terms.

The first step in showing that the refiner will select an inefficiently high level of retail sales in absolute terms is to rewrite equation [6-15] as[1]

$$[6\text{-}55]\quad \bar{P}m - Pp - \partial Am/\partial Vm - \partial Aw/\partial Vm + (\lambda_1+\lambda_4)(\partial Zm/\partial Vm + \partial Zm/\partial Vp) + (\lambda_2+\lambda_5)(\partial \hat{Z}m/\partial Vm + \partial \hat{Z}m/\partial Vp) = 0.$$

If it can be shown that

$$[6\text{-}56]\quad (\lambda_2+\lambda_5)(\partial \hat{Z}m/\partial Vm + \partial \hat{Z}m/\partial Vp) > 0$$

and that

$$[6\text{-}57]\quad (\lambda_1+\lambda_4)(\partial Zm/\partial Vm + \partial Zm/\partial Vp) > 0,$$

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1 This is accomplished by observing that: $\partial Zm/\partial Vm = \partial Zw/\partial Vm$, $\partial Zm/\partial Vp = \partial Zw/\partial Vp$, $\partial \hat{Z}m/\partial Vm = \partial \hat{Z}w/\partial Vm$, $\partial \hat{Z}m/\partial Vp = \partial \hat{Z}w/\partial Vp$, and that $Pm = \bar{P}m$.

then it must be the case that

[6-58] $\bar{P}m - Pp - \partial Am/\partial Vm - \partial Aw/\partial Vm < 0$,

which implies that in equilibrium the marginal cost of retail sales exceeds the retail price.

To show that these expressions are positive, expression [6-56] is rewritten as

[6-59] $(\lambda_2+\lambda_5)(Pm^\circ - Pp^\circ + 3 - \hat{Z}m + Pp)$.

Since $\hat{Z}m=Pm=\bar{P}m$, expression [6-59] must be positive if condition [6-5] is satisfied.

To show that expression [6-57] must be positive, $Vs-\lambda_2-\lambda_5-\lambda_3-\lambda_6$ is substituted for $\lambda_1+\lambda_4$ in equation [6-55], which may then be rewritten as

[6-60] $(Pm^\circ - Pp^\circ - Xs^\circ) + (\lambda_2+\lambda_5)(\partial\hat{Z}m/\partial Vm + \partial\hat{Z}m/\partial Vp)$

$$-(\lambda_2+\lambda_5+\lambda_3+\lambda_6)(\partial\hat{Z}m/\partial Vm + \partial\hat{Z}m/\partial Vp) = 0.$$

Since the first two terms are positive, the third term must be negative, which in turn implies that expression [6-57] must be positive. Thus, the controls induce the constrained refiner to select an inefficiently high level of retail sales in absolute terms.

The result that in this equilibrium the level of retail sales is inefficiently high relative to the level of wholesale sales is obtained by subtracting equation [6-16] from equation [6-15] and simplifying as before. This yields

[6-61] $\bar{P}m - \bar{P}w - \partial Am/\partial Vm + \frac{(\lambda_1+\lambda_4)}{Vs}(\partial Am/\partial Vm - J)$

$$+ \frac{(\lambda_2+\lambda_5)}{Vs}(2.25 - J) = 0.$$

Since $\lambda_1+\lambda_4$ and $\lambda_2+\lambda_5$ are positive, if $\partial Am/\partial Vm - J$ and $2.25 - J$ are both positive, it must be the case that

[6-62] $\bar{P}m - \bar{P}w - \partial Am/\partial Vm < 0,$

which implies that in this equilibrium the incremental cost of selling gasoline retail instead of wholesale exceeds the incremental revenue.

To show that $2.25 - J$ must be positive, it is observed that equations [6-10] and [6-11] imply that[1]

[6-64] $J = \bar{P}m - \bar{P}w - Pm^\circ + Pw^\circ.$

Therefore, if condition [6-4] is satisfied, $2.25 - J$ must be positive.

To show that $\partial Am/\partial Vm - J$ is positive, $Vs-\lambda_2-\lambda_5-\lambda_3-\lambda_6$ is substituted for $\lambda_1+\lambda_4$ in equation [6-61]. Equation [6-61] can then be simplified to[2]

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1 Since $\hat{Z}m=\bar{P}m$ and $\hat{Z}w=\bar{P}w$.

2 Since $\bar{P}m-\bar{P}w-J=Pm^\circ-Pw^\circ$.

[6-64] $(Pm^{\circ} - Pw^{\circ}) + (\frac{\lambda_2+\lambda_5}{Vs})(2.25 - J) -$

$$(\lambda 2+\lambda 5+\lambda 3+\lambda 6)(\partial Am/\partial Vm - J) = 0.$$

Since the first two expressions in equation [6-64] are positive, the final term must be negative in equilibrium, which implies that $\partial Am/\partial Vm - J$ is positive in equilibrium. Thus, the controls induce the constrained refiner to select an inefficiently high level of retail sales relative to wholesale sales in this equilibrium.

## Chapter VII

## EXCESS DEMAND

The preceding analysis has indicated that constrained refiners will frequently maximize profits by pushing their ceiling prices to the market clearing level. However, under certain conditions, some or all constrained refiners may find it most profitable to price below the market clearing level and face excess demand. In fact, shortages have occurred infrequently during the period of regulation; but they have occurred, and they can be expected to recur sporadically so long as the regulations are in place. In this section, the ways in which excess demand might be caused by the product price regulations are discussed. Four general causes of excess demand are examined. Three of them have been alluded to in previous chapters: sales in multiple markets, a negative or very low base period margin on product resales, and the upper limit on the pass-through of nonproduct marketing costs. A fourth possible cause, a form of regulatory lag, has not been discussed in the preceding analysis. The mathematical models employed in earlier chapters are not employed in this chapter because of the discontinuities that arise in non-market-clearing equilibria.

Before proceeding, it should be noted that oil companies are subject to forces, other than those incorporated in DOE regulations, that may sometimes cause them to hold their prices below the market clearing level. One is nonregulatory pressure from DOE

and another is the President's anti-inflation guidelines administered by the Council on Wage and Price Stability (COWPS). For instance, it has been widely reported that DOE requested U.S. refiners to avoid spot purchases in the world market during the 1979 supply disruptions following the Iranian revolution. DOE exercises considerable leverage on oil companies through its administration of both price and allocation regulations and was apparently able to elicit "cooperation." A key mechanism whereby refiners are able, under the regulations, to equilibrate domestic supply and demand is through purchases of imported petroleum--both crude oil and product. In the absence of such purchases, excess demand becomes a possibility, as discussed in chapter III.

FTC staff have also been informed by oil industry officials that in the spring and summer of 1979, COWPS price guidelines set lower limits on product price increases than did DOE regulations. To the extent that refiners conformed to the lower prices, COWPS guidelines rather than DOE price regulations may have explained instances of excess demand.

REGULATORY LAG

A feature of the regulations not incorporated in the models developed in the preceding chapters is that ceiling prices for the current month are based on the current month's output but the previous month's costs. This regulatory lag lends a degree of temporal inflexibility to pricing behavior that is not present in an unregulated market. The refiner's ceiling price at the end of

the month is influenced by costs he incurred nearly two months earlier. This is probably the most likely cause of widespread shortages.

If month-to-month changes in market conditions are not great and the refiner can properly anticipate them two months in advance, the regulatory lag may not have much impact. The firm should be able to schedule its purchases of inputs so that its ceiling price closely approximates the market clearing price. However, in the case of large (especially unexpected) changes in market conditions, the lag can make it unprofitable for refiners to equate their ceiling prices to the market price in the short run.

If the refiner anticipated a market clearing price of, say, $\bar{P}$ = P1, the preceding chapters suggest that he would have found it profitable to incur expenses such that Z = P1. However, if the price turns out to be P2 > P1, the regulated refiner is quite limited in the way he can alter his maximum allowable price in the short run.[1] He can raise his ceiling price only by reducing his output below the planned level so that his already incurred allowable costs are spread over a lower volume. The firm in this

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[1] A large increase in the price of crude oil over a short period of time could cause such a situation.

circumstance will find it more profitable to face excess demand. The refiner will only be able to profitably respond to the changed conditions in following months.

MULTIPLE MARKETS

If a firm operates in a number of markets, changes in equilibrium price differentials among markets may also make it profitable for the firm to accept excess demand in some of its markets. As discussed in chapter V, the equal application rule tends to tie the firm's ceiling price structure to the price structure that existed in the base period. At the outset of the regulatory period, each firm was required to designate classes of purchaser. Each class of purchaser presumably constituted a separate market (functional, geographic, etc.) in the base period. Subsequently, with minor exceptions, the firm's ceiling price is the same for every buyer in a given class, and the difference between the ceiling price levels for any two classes is the same as the difference between the base period prices for those two classes.[1,2]

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[1] The equal application rule, which causes this, has the admirable purpose of keeping sellers from calculating their ceiling prices in such a way that they are able to discourage purchases by buyers with allocation rights and channel their volume through their own operations at will. As pointed out in chapter VI, however, the rule has only limited effectiveness in achieving this goal.

[2] Subsequent to this analysis, effective November 1980, the equal application rule was suspended. The suspension eliminated the possible cause of shortages discussed in this section.

The pricing rigidities that this rule introduces may lead to excess demand if the refiner finds it impossible to simultaneously equate all of its class-of-purchaser ceiling prices to the relevant market clearing prices. This can happen if the differences among market prices in the current period have changed from those in the base period. For example, due to general inflation, it is likely that the equilibrium market clearing price differences among refinery gate, wholesale, and retail prices have all widened somewhat since the base period.[1] In this situation, as the refiner increases output to push his set of class-of-purchaser ceiling prices up, he will find that some of the ceiling prices will have risen to the market clearing level, while others are still below the market clearing level.

If a refiner faced a situation in which he could not simultaneously equate all his ceiling prices to the relevant market clearing prices, he could continue to push up his allowable costs and thereby his ceiling prices, until he generated a ceiling price for every class of purchaser that equaled or exceeded the relevant market clearing price. While this would allow the refiner to choose to sell at the market clearing price in each and every

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[1] The retail price adjustment exception to the equal application rule that was discussed in chapter V would permit the refiner to avoid excess demand if he sold only to one retail and one non-retail market. Refiners typically, however, sell in many markets, and the single degree of freedom introduced by this rule will usually be inadequate to permit the refiner to simultaneously equate all of his ceiling prices to the corresponding market prices.

market, it might not be profit maximizing. In the stylized case of a price-taker, for example, a firm is unable, due to competitive pressures, to sell any product at a price higher than the market clearing price. Thus, if the firm continued to sell products in the markets in which its ceiling price exceeded the market price, it would be able to charge only the market clearing price and would fail to recoup all of its allowable costs.[1] Previous results regarding the profitability of market clearing selling prices depend on the full pass-through of incremental increased allowable costs; in the absence of this condition, market clearing prices are not necessarily profit maximizing.

It might be thought that a firm that set some ceiling prices above the market clearing level as described above could avoid adverse profit effects by ceasing to sell in the markets in which its ceiling price was above the market clearing price. If the firm sold only in the markets in which the ceiling price just equaled the market clearing price, the firm would be able to recoup all of its allowable costs. While refiners may sometimes find this course of action profit maximizing, this is not necessarily the case. Those markets the firm would have to

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[1] It should be noted that the seller in this case would not even be able to attempt to collect the unrecouped costs at a later date if market conditions changed. The equal application rule does not allow a seller to bank costs if in a given period he sells to some buyers at a price below his ceiling price for those buyers' class of purchaser while he is selling to any other buyer at the ceiling price for the other buyer's class of purchaser. Readers unfamiliar with banked costs will find them discussed in chapter VIII.

abandon to achieve this result may be those in which the firm is able to earn the greatest profit margin. Conversely, the markets in which the refiner continued to sell might yield a much lower (or even negative) profit. In addition, the refiner might not be able to achieve a high volume of sales under this strategy, and profits are a positive function of volume as well as margin. For instance, a firm might transfer sales from the markets in which its ceiling price exceeds the market clearing price into those in which the ceiling price just equals the market clearing price. However, if the transfer of sales increased average allowable costs, the firm's ceiling price would reach the market clearing level in all markets at a lower total volume of sales than would have otherwise been the case.[1]

The foregoing discussion suggests strongly that while achieving market clearance in all markets is possible, it may reduce the firm's profits and consequently be an unattractive option in some circumstances. The alternative, of course, is for

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[1] The stylized price-taker model tends to exaggerate the cost to the seller of achieving market clearance in multiple markets. Since gasoline sellers tend to be differentiated by location and other characteristics, it is likely that they have some downward slope to their demand curves. In that case, there are a number of price/quantity combinations in each market that can result in market clearance for a given seller. This makes the prospect of market clearance more likely than in the stylized price-taker case, because the seller does not have to completely abandon a market in order to charge a ceiling price above some arbitrary level. There may be some optimal price/quantity pair from the seller's point of view, but he may not suffer a major decline in volume at somewhat higher prices. In addition, since less volume decline occurs when the selling price increases, it is more likely that the refiner will be able to transfer the lost volume to another market at a cost that makes the transfer attractive.

the refiner to achieve a market clearing price in only one or some of the markets in which he sells and to face excess demand in others.[1]

LOW BASE PERIOD MARGIN

Another reason that a refiner might find it most profitable to operate with a price below the market clearing level was implied in chapter III. The discussion following [3-17] indicated that increased product purchases by a refiner to achieve a market clearing price would not be profitable if the firm did not have a positive base period margin on resales. A very low base period margin might also prevent the market from clearing in the short term. The following is a possible example of this problem.

When Shell Oil was faced with (widely reported) excess demand for its premium unleaded gasoline in October and November 1978, it could have purchased more product than it actually did on the spot market in order to push the ceiling price of its unleaded gasoline to the market clearing level. While there was no spot gasoline that met Shell's specifications for premium unleaded, Shell could have purchased regular leaded gasoline on the spot market and sold it at the best price that could be obtained. The sales of the

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[1] It should be noted that the existence of the allocation regulations makes market clearing pricing in the multiple market situation somewhat more likely. This is because the failure of the refiner to achieve a market clearing price in a nonretail market may mean that the allocation regulations will force him to distribute product in a radically different way than that which would maximize his profits.

additional leaded would presumably not have covered their cost because of the high spot purchase cost. However, the unrecovered costs of the extra leaded sales including a margin on each gallon could have been counted as a cost in computing the ceiling price for unleaded premium.[1] This process could have been carried to the point that increasingly expensive sources of spot leaded gasoline (and/or a lower price received for domestic sales) caused the ceiling price of unleaded premium to rise to the market clearing level. Shell would have captured, over and above the cost of the spot gasoline, the base period margin on each additional gallon of leaded regular sold.

When questioned about this strategy by the FTC, Shell management indicated that a primary reason it was not employed to the extent described above is that Shell has an unusually low base period margin on resales of leaded regular gasoline. As a result, Shell management claimed that possible adverse effects (such as the appearance of price-gouging on unleaded sales or adversely affecting independent marketers who rely heavily on spot purchases) outweighed the prospect of a relatively small profit gain.[2]

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1 For the purpose of computing ceiling prices, the regulations allow costs to be allocated among different types of gasoline at the refiner's discretion.

2 Shell may have had other reasons. The shortage was apparently unanticipated and, once it arose, its duration underestimated. As pointed out above, keeping one's ceiling price at the market clearing level (profitably) may require reasonably accurate predictions of market conditions at least one month in advance.

UPPER LIMIT ON MARKETING PASS-THROUGH

The upper limit on the amount of pass-through allowed for marketing nonproduct cost was described in chapter VI. If that limit is binding on a marketer, the effect of the DOE regulations becomes very much like that of traditional price ceilings, and sellers may not be able to achieve market clearing ceiling prices. For reasons discussed in chapter VI, however, it is believed that the marketing cost limit will rarely prevent refiners from achieving market clearing prices.

EXCESS DEMAND FOR INDIVIDUAL REFINER'S OUTPUT

Excess demand, when and where it does occur, is most likely to be restricted to one or a few sellers. All sellers in a market should seldom have ceiling prices below the market clearing level simultaneously. This is due to the firm-specific nature of the price control system. Different sellers face different anticipated and realized cost, market conditions, and base period parameters. For the reasons discussed above, some sellers may find it profitable to price below the market clearing price, face queues of customers seeking a low price, and wind up turning customers away. Consumers turned away from the low-priced suppliers (and customers unwilling to seek out those suppliers or to wait in line) will normally, however, be able to buy all the fuel they want from other sellers who find it profitable to charge a higher, market clearing, price. It should be noted that even if a number of sellers in a market are pricing below the market clearing

level, they are each likely to be charging a different price because of the firm-specific price ceiling.

PRICE IMPLICATIONS OF EXCESS DEMAND

It should also be noted that excess demand does not imply that a price is low in any absolute sense; it only implies that the price is not high enough to bring the quantity demanded down to the same level as that supplied. If the regulations are resulting in an output lower than the free market output (which has been shown in previous chapters to be a possibility) then a price below the market clearing level for that output could still be higher than the price that would prevail (and clear the market at a higher output) if the market were unregulated.

# CHAPTER VIII

## ARE THE REGULATIONS BINDING?

Although empirical analysis of the effects of the price regulations is beyond the scope of this study, the study does have an important message for those attempting empirical analysis of the regulations' effects or assessing the analysis of others. The message is that conclusions based on empirical observation must take into account the unique effects of the DOE regulations if they are to be meaningful. To date, most empirical work has been based on theoretical models that are incomplete or inappropriate to the conditions created by those regulations. In this chapter, the need for good modeling is illustrated by examining some misleading conclusions that have been reached concerning what appears to be a simple empirical question: have the regulations generally been binding?

Most of the empirical work concerning the regulations has involved estimating the effect of decontrol on the level of petroleum product prices. Some proponents of decontrol have argued that the regulations are nonbinding. They have used this argument to counter the fear that decontrol will result in higher prices. If the regulations are nonbinding, it follows that normal market

forces are already determining prices and decontrol will have no effect.[1]

Three types of empirical evidence have been advanced at various times to support the proposition that controls are nonbinding. They are: (1) the observation of market clearing prices (i.e., absence of shortages), (2) information on imported petroleum products, and (3) information on "banked cost." Each type of evidence is considered below; and it is seen that when evaluated in light of this study's analysis, none of this evidence is persuasive.

THE IMPLICATIONS OF MARKET CLEARING PRICES

The market clearance evidence can be dismissed most easily. The analysis of the preceding chapters indicates that no conclusion can be drawn about whether or not the DOE regulations are binding based on the observation that the controlled markets are clearing. Market clearing prices may prevail whether or not the price regulations constrain the behavior of firms. Therefore, the absence of shortages does not imply that prices would be unaffected by decontrol. Conclusions to the contrary are apparently the result of applying the traditional textbook model of

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[1] The possibility advanced in this study, that decontrol might lower prices, has apparently not been recognized even by proponents of decontrol. Similarly, various DOE estimates of the effect of decontrol on product prices have apparently ignored the factors that could cause prices to decline due to decontrol. For example, see U.S. Department of Energy, Final Environmental Impact Statement: Motor Gasoline Deregulation and Gasoline Tilt, January 1, 1979.

price controls to the petroleum industry. But, that model does not properly capture the effect of DOE controls.[1]

THE IMPLICATIONS OF IMPORTED PRODUCT

Some analysts have observed that refined product is being imported into the U.S. and have concluded from that observation that petroleum price regulations are not binding.[2] The fact that products are being imported is not, however, sufficient evidence upon which to base this conclusion.

The proponents of this argument reason that if the delivered cost of imported product is no greater than the U.S. market price, then foreign competition, not the price controls, is setting the upper bound on U.S. price levels. In this situation, if domestic

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1 The occurrence of excess demand appears to be compelling evidence that the controls have been binding, at least in the markets and during the times in which the shortages have been observed. However, this evidence must be accepted cautiously. In chapter VII it was pointed out that voluntary behavior requested by DOE and COWPS may have been responsible for some observed shortages. In addition, some empirical observations may be erroneously interpreted as signaling excess demand. For example, refiners frequently announce monthly "allocation fractions" of less than 100 percent. A refiner that makes such an announcement is saying that he does not expect to supply as much product in that month as he is required to offer his historic customers under the allocation regulations. However, since customers do not always buy their full allocation, this does not necessarily mean that the refiner faces excess demand in that month.

2 The originators of this argument are Charles E. Phelps and Rodney T. Smith. See Petroleum Regulation: The False Dilemma of Decontrol, Santa Monica, Calif.: The Rand Corporation, January 1977, and their editorial in the September 28, 1977 Wall Street Journal. The analysis of this report indicates that the central thesis of Phelps and Smith--that decontrol will not cause price increases--may be correct even if their argument that controls are nonbinding is incorrect.

sellers attempted to raise their prices following decontrol, buyers would simply purchase imports at the predecontrol price.[1] The proponents then argue that the importation of product must imply that the delivered cost of foreign product is not more than the U.S. market price. This argument is based on the assertion that "no importer would be willing to pay the world market price, only to sell at a lower domestic price."[2]

The analysis of this report, however, indicates that U.S. refiners when constrained by DOE regulations may profit by reselling product at a price lower than the cost of the product to them. This conclusion was implicit in the discussion following conditions [3-16] and [3-17]. Condition [3-16] implies that if, at the equilibrium level of his own refinery runs (Vr), the refiner's ceiling price is below the market clearing level, the refiner generally can profit by purchasing product at prices well above the market clearing price level. This is true despite the

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[1] This reasoning is essentially correct given an assumption of perfectly elastic foreign supply and assuming that the United States is a single market. The first assumption is necessary to counter the possibility that decontrol might push up both the U.S. and the world price. The second assumption is necessary to counter the possibility that the regulations are binding in some geographical markets (e.g., inland) even though imports are setting the upper limit in other (e.g., coastal) markets. Both of the assumptions are somewhat questionable.

[2] Op. cit., Phelps and Smith, Petroleum Regulation . . . , p. 24.

fact that the ceiling price at which the purchased product can be resold is lower than the cost of the purchased product.[1]

THE IMPLICATIONS OF BANKED COSTS

An element of the ceiling price not included in the models of this study is commonly referred to as "banked cost." The refiner computes his ceiling price by adding specified average cost increases to his base period price. If in a given month a refiner charges less than his ceiling price, he can generally increase his ceiling price in future periods to recover the revenue forgone. For example, if the refiner whose behavior was modeled in chapter III had no banked costs in a given month, his ceiling price would be shown by Zm in [3-5]. If in that month he sold at price Pm such that

[8-1] $ZmVm - PmVm = H > 0,$

his banked costs then equal H. In the next month the refiner's ceiling price would be[2]

[8-2] $Zm + H/Vm.$

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1 In this respect, it is interesting that a careful comparision of U.S. and world gasoline prices for the years 1975 through 1977 indicated that the delivered cost of foreign product generally exceeded the U.S. market price even at major U.S. ports. See Robert T. Deacon, "An Economic Analysis of Gasoline Price Controls," Natural Resources Journal, October 1978, pp. 801-14. Deacon also noted that domestic firms' profits may not be reduced by their purchasing imported product and reselling in the U.S. at a lower price.

2 There are limitations, some of which are noted below, on the way that banks may be built up and drawn down, but this is the essence of the system.

Banked cost was not incorporated in the models of this study because it would simply have added intertemporal complexity with no qualitative change in the analysis.

Data on banked costs have been used in some efforts to determine whether or not the controls have been binding. The logic of using banked costs for this purpose stems from the observation that a refiner generates and maintains banked costs by pricing below his ceiling price. If a refiner who prices below his ceiling price is necessarily unconstrained by the regulations, it follows that refiners who generate banked costs or maintain pre-existing banked costs in a given month are unconstrained in that month.

There are problems with the available banked cost data that limit their usefulness for testing whether the controls have been binding. These data problems are discussed in detail below. Before addressing the data problems, however, it is important to consider a more fundamental objection to the use of banked costs for identifying constrained refiners.

Assuming an accurate accounting of refiners' banked costs, one could not really conclude that every refiner that created or maintained banked cost was unconstrained. The models of this study imply that only an unconstrained refiner would choose to

generate banked costs[1]; and they imply that only an unconstrained refiner would fail to draw down an initial endowment of banked cost. However, the analysis of this study is a steady-state, certainty analysis that may not illuminate some situations in which a constrained refiner would profit from accruing or maintaining banked costs.

Most obviously, if uncertainty were introduced into the analysis, a constrained refiner might inadvertently generate positive banks. This could happen because a refiner's precise ceiling prices can be computed only after a full accounting of the month's business is made. For the same reason, uncertainty might cause a refiner to inadvertently generate negative banked costs. Since the regulations prohibit a firm from having negative banks two months in a row, this prospect might cause a refiner to purposely aim for a positive level of banks to avoid unintentional violation of the law. If in addition to uncertainty, fluctations in market conditions were recognized, it might be found that constrained refiners would intentionally build banked costs in one period with the expectation that they would be drawn down in subsequent

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1 Under the equal application rule, a refiner must set all of his class of purchaser selling prices below the relevant ceiling prices in order to generate banked costs. The models of this study imply that a constrained refiner will always equate at least one of his selling prices with the relevant ceiling price.

periods when market or cost conditions provided better profit opportunities.[1]

It seems clear that in a dynamic, uncertainty model, the creation or maintenance of banked costs would not be confined to unconstrained refiners; and thus, an unconstrained refiner could not be defined simply by this criterion. In such a model, an unconstrained refiner could be defined as one who had an expected present value of zero for incremental banked costs.[2] However, expected values are not observable. Furthermore, while an expected marginal value of zero would probably be associated with some absolute level of banked cost, that level would undoubtedly depend on numerous parameters that would vary across firms and over time for the same firm. It is therefore not known whether a banked cost level of 1/2 cent, 2 cents, 3 cents, or more per gallon of monthly sales conclusively identifies an unconstrained refiner.

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1 Such behavior might account for the pronounced seasonality in the level of banked costs. This seasonality is somewhat apparent in table 1 below.

2 Thus, if the present value of the incremental dollar of bank were 10 cents, the refiner would not use up bank in the current period unless he earned 10 or more cents additional profit in doing so. Probably the most important factor reducing the value of a dollar of bank in the current period is the equal application rule. Thus, suppose that a refiner sold equal volumes of gasoline at 10 class of purchaser prices and the ceiling price for nine of these classes of purchaser were at or above the corresponding market price. If the refiner were to use his bank to raise his ceiling price to the remaining class of purchaser, he would earn only 10 cents per dollar of banked cost used.

Without knowing this, it is impossible to be sure, based on banked cost data, which firms are unconstrained.[1]

Even if it is assumed that some level of banked cost can be identified, above which a refiner is surely unconstrained, the banked cost data that have been advanced to support the argument that the controls have generally been nonbinding are subject to theoretical and empirical problems. The problems with aggregate banked cost data and individual refiner banked cost data are discussed in turn below.

The Level Of Aggregate Banks

The DOE collects data from refiners on the level of their banked costs and publishes the data after aggregating across companies. These aggregate banked cost figures have generally been quite large and have led some to conclude that the price controls have generally been nonbinding. The caveats expressed in the preceding section suggest that positive banked cost for an

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[1] The only refiners which can confidently be said to be unconstrained are a group of small refiners whose banked costs are so large that they have refused to complete portions of the DOE Form EIA-14. The basis for the refusal is that the cost of the calculations exceeded the value of the additional banked costs that would thereby be earned.

While positive or increasing banks appear to have limited value as evidence that a refiner is unconstrained, very low or zero banks seem to be persuasive evidence that a refiner is unconstrained.

individual refiner might not indicate that the refiner is unconstrained.[1] Even aside from these problems, however, aggregate banked cost data are essentially meaningless, since some firms can be constrained while others are not. The results generated in the preceding chapters require only that some refiners be constrained.

The misleading nature of aggregate banked cost data can be illustrated by examining banked cost data prepared for the FTC. Although firm-specific banked cost data are treated as confidential by the DOE, DOE did provide some calculations from this data which illustrate the highly varied level of individual firm banked costs. These data, which are presented in table I, show the number of refiners with various levels of total banked costs per gallon of monthly gasoline sales during four 3-month periods in 1977 and 1978.[2] In each of these periods, there were extreme differences in the banked cost levels of the refiners in the sample. Furthermore, it seems quite likely that at least those firms with less than 1/2 cent of banked costs per gallon of monthly gasoline sales were constrained by the controls. Thus, despite the fact that 1977 and 1978 were years in which markets cleared and

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1 The difficulties in interpreting individual refiner banked cost data are discussed in detail below.

2 The derivation of the data which appears in table I is explained in the footnotes to that table. A variety of potentially serious deficiencies in this data are considered below in the discussion of individual refiner banked cost data.

aggregate banks were very large, table I indicates that several refiners were probably constrained by the controls in this period.

In addition, since the largest refiners are more likely to be constrained by the controls,[1] the impact of the controls on the gasoline market is likely to be greater than suggested by the ratio of constrained to unconstrained refiners. DOE attempted to downplay the significance of the controls in April 1977 by noting that, at that time, only 3 of the top 30 refiners appeared to be constrained and that these 3 refiners had "less than one-fifth of the gasoline market."[2] However, while the actual market share of these 3 firms is not known[3] (nor is the market share of the firms in the table I data), a market share at all close to 20 percent suggests a potentially large impact of the controls.

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1 The reasons for this presumption were discussed previously. Probably the most significant is the fact that only the large refiners were subject to Special Rule #1 on May 15, 1973.

2 Office of Regulatory Programs, Federal Energy Administration, Final Report, Findings and View Concerning the Exemption of Motor Gasoline From the Mandatory Petroleum Allocation and Price Regulations, Sept. 1977, p. 116.

3 It is also not known what criteria DOE used to determine that no other refiners in the top 30 were constrained. The discussion of the preceding section indicated that even firm-specific data provide only minimum estimates of the number of firms constrained by the controls.

Table I The Distribution of Refiner Banked Costs

| Total Banked Costs in cents per gallon of monthly gasoline sales[1] | June-August 1978 | Jan.-March 1978 | June-August 1977 | Jan.-March 1977 |
|---|---|---|---|---|
| 0- .5¢/gallon | 5 | 3 | 5 | 4 |
| .5 - 4¢/gallon | 6 | 3 | 6 | 2 |
| 4-20¢/gallon | 17 | 14 | 17 | 21 |
| 20-40¢/gallon | 13 | 18 | 12 | 15 |
| 40-75¢/gallon | 12 | 9 | 14 | 11 |
| greater than 75¢/gallon | 12 | 18 | 11 | 12 |
| total | 65 | 65 | 65 | 65 |



1 The total banked cost per gallon was calculated by adding the figures appearing in item 38 columns d,e, and f (Total Unrecovered Costs Not Including Month of Measurement Costs [After Reallocation] for aviation jet fuel, gasoline, and general refinery products) of Part IV of the form EIA-14 in each month of each three month period. The total for each three month period was then divided by total gasoline sales. Total gasoline sales were computed by adding the figures appearing in item 1 column B (Total Motor Gasoline) in Part III of the form P302-M-1 for each month in each three month period.

2 The basic sample consisted of all refiners filing both the EIA-14 and the P302-M-1. Of these, 19 refiners were deleted from the sample because they did not allocate crude costs to motor gasoline in all months. Were staff able to examine the actual data less extreme measures could have been taken to exclude asphalt refiners and other atypical refiners. Given the inability to directly observe the data, total exclusion seemed to be the best course of action. Although staff do not know the identity of any of the firms in any individual category nor the identity of all firms in the sample, staff has been assured that the sample includes all "major" and "large independent" refiners.

The Level Of Individual Refiner Banks

The discussion above clearly rejects the use of aggregate banked costs data in any form to conclude that the controls are not binding. The natural alternative is to employ company-specific banked cost data for this purpose. However, even the disaggregated banked cost data collected by DOE have two serious flaws. First, the data submitted to DOE do not show how much bank was available to be applied to any given product. Second, the data are not routinely verified, and there is reason to believe that firms have typically reported a higher level of banks than they assume for their own decisionmaking. These problems are discussed in detail below.

The reason that product-specific banked cost data are necessary is that the regulations have limited the freedom of refiners to recover banked costs in the sales of one type of product when those banked costs were earned on a different type of product.[1] For example, during 1977 and 1978, no banked cost earned on gasoline sales could be reallocated to other products, while some, but not all, banked costs earned on other products could be reallocated to gasoline. Thus, while the banked costs in table I were calculated as an amount "per gallon of monthly gasoline sales," that was simply an arbitrary way of displaying the

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[1] The limitations have changed frequently over the history of the regulations. It should also be noted that the absence of product specific information was a more pronounced flaw in the data for analysis of years in which many or all products were controlled.

magnitude of the banks in an intuitively meaningful perspective. There is no way of knowing how much of those banked costs could legally have been applied to gasoline pricing. Even if the reported banks were fully allocable to gasoline pricing and were of a magnitude to suggest (based only on gasoline) that refiners were unconstrained, it is possible that banks available for other products were low and that refiners were still constrained as a result.[1]

There are a number of alternative calculations of individual refiner cost banks which could be performed employing the data collected by DOE. No matter how manipulated, however, the data do not permit determination of the actual level of banked costs available for the pricing of particular products. At best, additional calculations could place a lower limit on the banked costs available for gasoline pricing for each refiner.

Two sets of DOE data are available which illustrate the potentially misleading nature of the data in table I. First, the ratio of gasoline to all controlled products by volume is available for each of the banked cost categories in table I by month. This information is presented in table II. It is apparent that there is a strong relationship between a high estimated banked cost level in table I and a high proportion of controlled products other than gasoline. This relationship could exist because

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1 If even constrained refiners desire to hold some positive level of banks for reasons suggested at the outset of this chapter, it is likely that positive banks are desired to some degree on all types of controlled products.

Allocation of Gasoline to All Controlled Products by Banked Cost Level[1,2]

| Period | Banked cost intervals in cents/gallon of monthly gasoline sales (June, July, August 1978)[3] | | | | | |
|---|---|---|---|---|---|---|
| | 0-.5 | .5-4 | 4-20 | 20-40 | 40-75 | 75+ |
| August 1978 | .9724 | .9177 | .8959 | .9293 | .9062 | .8971 |
| July 1978 | .9698 | .9260 | .9058 | .9284 | .9100 | .8842 |
| June 1978 | .9716 | .9251 | .8989 | .9358 | .9008 | .8200 |
| March 1978 | .9708 | .9142 | .8495 | .9265 | .8731 | .8602 |
| February 1978 | .9697 | .9082 | .8432 | .9128 | .8891 | .8684 |
| January 1978 | .9538 | .9217 | .9003 | .9332 | .8875 | .8438 |
| August 1977 | .9555 | .9188 | .9048 | .9123 | .8920 | .8494 |
| July 1977 | .9211 | .9183 | .9066 | .9108 | .8963 | .7945 |
| June 1977 | .9341 | .9192 | .9027 | .9119 | .8985 | .8384 |
| March 1977 | .9531 | .9162 | .9079 | .9137 | .8932 | .8472 |
| February 1977 | .9439 | .9106 | .9029 | .9213 | .9139 | .7652 |
| January 1977 | .9533 | .9124 | .9095 | .9307 | .9126 | .7642 |

[1] The volumetric ratios are calculated by summing the figures appearing in item 27 column d (Allowable Cost Increases, Crude Oil-Gasoline) across the refiners in each banked cost interval and dividing by the sum across the refiners in each banked cost interval of the figures appearing in item 27 column i (Allowable Cost Increases, Crude Oil-Total) in Part IV of the EIA-14. This calculation yields the volumetric ratio because crude oil costs are allocated to each product on the basis of volumetric ratio (pre-tilt). It should be noted that the refiners in each banked cost interval are held constant because the June-August 1978 groupings are used in calculating all of the monthly ratios.

[2] The sample is the same as described in Table I.

[3] The banked cost intervals are calculated as described in Table I.

refiners are less likely to be constrained by the controls, the larger their proportion of nongasoline controlled products. This relationship is also consistent, however, with the hypothesis that the procedure used to calculate banks for table I materially overstates the banked cost applicable to gasoline.

It is also interesting in this context that DOE data show that 35.2 percent of all banks were attributable to nongasoline controlled products.[1] Since this proportion is considerably larger than the proportions of these products in the volumetric output mix, incorrect allocation of these banks can clearly have a considerable impact on the apparent pricing freedom provided by banked costs.

The second problem with the individual refiner banked cost data reported to DOE is that they are likely to overstate refiners' actual levels of banked cost. This overstatement arises because refiners will naturally tend to report the level of banked cost that results when calculations are made using assumptions favorable to the refiner. There have been substantial differences between refiners and DOE over the interpretation of many elements of the regulations. Differences in interpretation may sometimes be discovered only after an audit and may require a DOE ruling or

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1 Op. cit., Final Report ..., calculated from table IV-13, page 114.

a court decision for resolution. Furthermore, even after differences in interpretation are resolved, the resolution is not reflected in historical banked cost data.

This problem would not be important if refiners made their pricing and output decisions on the basis of the banked costs reported to DOE. However, if a refiner believes a subsequent audit is likely to result in DOE disallowing most or all of his claimed banks, the refiner may choose to behave as if he did not have these banks and is therefore constrained. By doing this, the refiner can avoid DOE penalties that are levied for charging prices in excess of those allowed by the regulations.

While some refiners may have believed that their claimed costs were indisputable, it seems reasonable to assume that most refiners have anticipated that an audit would dispute their claims. To the extent that the latter refiners were able to predict the resolution of the dispute with reasonable accuracy, DOE audit results may give some idea of the degree to which reported banks must be reduced to yield a meaningful figure for judging whether or not those refiners were constrained.

The DOE audits of the top 15 refiners indicate that the impact of differences in interpretation of the regulation over the 1973-1976 period was potentially sufficient to generate more than 75 cents of banked cost per gallon of monthly gasoline sales for most of the refiners audited. Since this corresponds to the highest banked cost level in table I, it is clearly possible that the data in that table are misleading.

Before examining the audit results, it should be explained why they are an imperfect indicator of the probable overstatement in historical DOE banked cost data. One reason for this is uncertainty about the extent to which the post-audit DOE overcharge claims reflect the actual resolution of the disputes. Comments in the trade press suggest,[1] accurately or not, the possibility that the DOE claims were inflated by questionable auditing procedures and do not represent the real basis for settlement. In addition, since the actual settlements provide for combinations of compensation provisions,[2] it is difficult to place a dollar value on the amount of overcharges even in cases finally resolved. Also, since these overcharge cases apply not only to gasoline prices but also to other products, such as natural gas and products that are now decontrolled, the amount of overstatement in gasoline banks cannot be readily deduced.

The first example indicating past overstatement of banked costs concerns Standard Oil Company of Indiana. DOE recently settled $500 million of alleged overcharges with this company. Not only does this example illustrate the potential magnitude of

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1 "Flurry of U.S. Government Price Allegations Ebbing," The Oil and Gas Journal, January 28, 1980. See particularly p. 78.

2 These include not only reductions in banked cost, price rollbacks, and rebates to past customers, but also mandatory crude purchases and heating oil production, increased exploration, development, and product expenditures, and capital expenditures on desulfurization facilities.

past distortions in banked costs, but it also typifies the settlements which are difficult to evaluate in dollar terms. While the total of the alleged overcharge is indicated to be about $500 million, the settlement package was valued by DOE at $700 million. The constituents of this settlement, as reported in the Oil and Gas Journal, indicate a real settlement value considerably below the $700 million figure. The agreement calls for $29 million of rebates to past buyers of diesel fuel and home heating oil, $71 million to be disbursed "to persons affected most by rising energy bills." Future price increases for gasoline and propane of $180 million are to be forgone, which presumably means a $180 million reduction in the banked costs for these products. In addition, the settlement calls for $25 million in rebates to current customers through a reduction in current prices, $250,000 in penalties paid to the government and $411 million in capital outlays.[1] The last provision is meaningless if it requires investment which would have been made anyway; and its cost to the refiner is very hard to evaluate otherwise. If the investment cost is excluded in valuing the settlement, the package amounts to $325.25 million, or about 61.5 percent of the alleged overcharges.

The approximate level of Standard of Indiana's 1977 monthly gasoline sales calculated from National Petroleum News data was a

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1 "Indiana Standard Settles Price Violation Charges," The Oil and Gas Journal, Feb. 25, 1980, p. 38.

little over 700 million gallons a month.[1] Thus, the alleged overcharge amounts to about 75 cents per gallon of monthly gasoline sales, the dollar value of the settlement package (excluding capital investment) amounts to about 45 cents per gallon of monthly gasoline sales, and the banked cost reduction amounts to about 27 cents per gallon of monthly gasoline sales.[2] Clearly, the potential magnitude of the past distortion in Standard of Indiana's banked costs is so large that historical banked cost data cannot be employed to ascertain if or in what periods the firm was constrained by the regulations.

A second indication of the potential magnitude of overstated banked costs is provided by the size of the government's post-audit overcharge claims against Texaco, Exxon, Gulf, Mobil, Shell, Arco, and Chevron.[3] Although the settlement terms in these disputes are not known, if the amount of the claims is compared to the firms' 1977 monthly gasoline sales, the overcharge claims

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1 1978 National Petroleum News Factbook Issue, p. 110.

2 These calculations should be recognized as ballpark estimates which disregarded the fact that National Petroleum News branded sales data is not the same as a firm's total gasoline sales; not all of these overcharges relate to gasoline; and some disputes may have been settled previously. In addition, it is not clear whether the overcharge claims in question related to the 1973-1976 period or covered the 1976-1979 period as well. The February 25 article indicates the latter, but the January 28 article (which presents a much lower overcharge figure for Standard of Indiana) states that the 1976-1979 audit would not begin until the fall of 1980.

3 Op. cit., "Flurry ... Ebbing," p. 76.

amount to a dollar or more per gallon of monthly gasoline sales for each refiner other than Chevron (for which the ratio is slightly under one dollar). If the settlement terms for these claims followed the Indiana pattern, the banked cost reductions alone would exceed 36 cents per gallon of 1977 monthly gasoline sales.[1]

THE COEXISTENCE OF BANKED COSTS AND PRODUCT IMPORTS

It does not appear possible to determine precisely which firms are unconstrained using available banked cost data. Nevertheless, it seems likely, even from aggregate data, that at least some firms have been unconstrained in most months that the regulations have been in force. This fact, combined with the observation that imports have occurred in most periods, might seem to suggest that the price of imports has set the upper limit on domestic product prices and that the price regulations have thus been nonbinding. Even constrained refiners who are willing to pay high prices to obtain product for resale will find it more profitable to buy product at the lowest possible price. Therefore, refiners will never import gasoline having a higher delivered cost than gasoline which can be purchased from an unconstrained domestic refiner.

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1 The use of these very rough calculations should not be taken to mean that these are the best estimates that can be derived from available information. However, even if precise settlement data were obtained, it would still not be known to what extent the actual settlements reflected the refiners' expectations about them. Furthermore, it is not known how expected settlements would have affected past refiner behavior. In view of these problems, additional precision would seem to be of little value.

While each of these arguments is essentially correct, it does not follow that if refiners import gasoline, and not all refiners are constrained, then the domestic price level must reflect the foreign price level. The price at which unconstrained refiners sell gasoline to constrained refiners need not have any relationship to the price at which gasoline is sold to consumers. To see this, suppose that the unconstrained refiners in the relevant market sell their entire gasoline output to the constrained refiners at the price of imported gasoline. The domestic price level is still determined by the controls rather than by the price of imported gasoline. In this context, it is perhaps noteworthy that the Oil Daily gasoline price quotations for cargo lot sales at Texas Gulf ports were above downstream prices for essentially all of 1979.

## CONCLUSION

This chapter illustrates some of the misleading conclusions that can be drawn from empirical data in the absence of appropriate theoretical analysis of the regulations' effects. Unfortunately, the theoretical modeling done in this study indicates that good empirical work will be very difficult. This is implicit in two conclusions that appeared frequently in the preceding chapters. First, determining even qualitative, comparative static, effects for a given firm often requires specification of the firm's production function. Second, because firms faced different base period conditions, the regulations may affect each of them

fferently even if each has the same production function. These
o conclusions indicate that the information requirements for
od analysis may be enormous, perhaps even insuperable. How-
er, the danger of misleading results is very real if incomplete
dels with less demanding data requirements are used.

## ALGEBRIC NOTATION

### Basic Notation

$\lambda$: Lagrangian multiplier

$\Pi$: Profit

A: Total cost for inputs whose costs are fully allowable (e.g., crude oil cost)

B: Total cost of purchased product

G: Fraction of refined output volume that is price controlled

H: Banked costs

J: Cost reallocated from other functional marketing levels to retail

K: Measure of capital input

M: Base period margin

N: Total capital costs that are allowable

P: Choice price

$\bar{P}$: Market clearing price

Q: Measure of crude oil input

R: Total capital costs that are not allowable

V: Volume of refined product output

X: Summary notation

Y: Summary notation for increased allowable cost

Z: Ceiling price under the regulations

### Superscripts

no superscript: Denotes current period value

o: Denotes base period value

ALGEBRAIC NOTATION (CONTINUED)

Subscripts

m: Retail

p: Product purchased by subject refiner

r or no subscript: Refinery

s: Total all distribution levels

t: Indicates that the "tilt" regulations were incorporated in calculating the value

u: Uncontrolled product

w: Dealer tank wagon

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